Understanding Challenges and Opportunities in Body Movement Education of People who are Blind or have Low Vision

Madhuka De Silva
Monash University
Australia
madhuka.desilva@monash.edu

Sarah Goodwin
Monash University
Australia
sarah.goodwin@monash.edu

Leona Holloway
Monash University
Australia
leona.holloway@monash.edu

Matthew Butler
Monash University
Australia
matthew.butler@monash.edu

ABSTRACT

Actively participating in body movement such as dance, sports, and fitness activities is challenging for people who are blind or have low vision (BLV). Teachers primarily rely on verbal instructions and physical demonstrations with limited accessibility. Recent work shows that technology can support body movement education for BLV people. However, there is limited involvement with the BLV community and their teachers to understand their needs. By conducting a series of two surveys, 23 interviews and four focus groups, we gather the voices and perspectives of BLV people and their teachers. This provides a rich understanding of the challenges of body movement education. We identify ten major themes, four key design challenges, and propose potential solutions. We encourage the assistive technologies community to co-design potential solutions to these identified design challenges promoting the quality of life of BLV people and supporting the teachers in the provision of inclusive education.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in accessibility**.

KEYWORDS

blind, low vision, body movement, education, design challenges

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1 INTRODUCTION

Accessing body movement educational programs in recreational and physical activities, such as sports, exercise, martial arts, and dance, is challenging for people who are blind or have low vision (BLV). This impacts the fitness of BLV people [20, 38], contributing to higher levels of sedentary behaviours [101], becoming less actively involved with the world [60, 96], and having less aesthetic and physical literacy. This can result in lower quality of life than people who are sighted [40, 96, 105]. Teachers of body movement primarily educate their students by instructing them to copy their demonstrations [24]. However, visual cues play little or no role in educating BLV people in body movement. Instead, they mostly rely on verbal instructions provided by the teachers [95]. Verbal instructions tend to be ambiguous [27, 95], and the style of instruction creates friction in understanding the movement [12]. Physical interactions or touch demonstrations are also used in addition to verbal instructions when educating BLV people in body movement [25, 77, 95]. However, physical guidance and touch can lead to misinterpretation and are unsuitable for students sensitive to touch [41, 77]. In addition to formal face-to-face educational methods, there has been a recent rise in videos and other online content for physical activity programs. This has been particularly evident in recent years, where we saw a huge increase in remote learning globally due to the Covid-19[1] lockdowns [16, 17, 67]. However, it is questionable as to what extent remote content supports BLV people's learning, as most of the content is of a visual nature.

Several HCI and accessibility research studies have been conducted aiming to support BLV people's participation in body movement activities such as sports [2, 21, 69, 73, 107], and exercise [62, 71, 72, 89], but fewer in creative body movement activities such as dance [22]. Some of those studies support the learning aspect by contributing to understanding body movement concepts and ensuring making proper adjustments [22, 89], whereas a majority address assistance and training needs that enhance the performance of the already learned concepts or techniques [69]. Further, only a few studies have consulted teachers of particular activities [7, 21, 22, 89], with little to no focus on addressing challenges experienced by teachers when educating BLV people. Another gap is that only some solutions are based on an initial exploration of the needs of

[1]COVID-19 is a highly infectious respiratory illness caused by the SARS-CoV-2 virus that first emerged in December 2019 and has since caused a global pandemic with substantial impacts on public health, society, and the economy.

BLV people [47, 88], and little is known about how BLV people or their teachers adopt technology driven tools in body movement education.

To address these gaps and understand the problem space following the recommendation to "start with a problem instead of the technology" [98], we conducted a series of three studies with BLV adults and teachers who have experience in educating BLV people: a preliminary survey; semi-structured interviews; and focus group discussions. We aimed to answer two main research questions: (1) What are the current body movement learning methods, teaching techniques and tools for educating BLV people? and (2) What are the challenges and priorities of access to learning or teaching body movement for BLV people? From the thematic analysis of the data, **the primary contribution of this paper is four key design challenges** that we encourage the assistive technologies community to consider when co-designing potential solutions to improving access to learning body movement for BLV people and supporting their teachers in providing an inclusive body movement education: (1) Representation of body movement to support verbal instructions, (2) Supporting feedback and improving kinesthetic awareness, (3) Supporting spatial and social interactive body movement learning and (4) Supporting accessible remote learning.

2 RELATED WORK

In this section, we first discuss the exploration of barriers to engagement in body movement for blind or low vision people and briefly explain the need for further research We then describe current educational practices for students with vision impairments. Finally, we discuss technological innovations of different body movement access methods. Note, we use **'body movement'** instead of physical education or exercise not to limit our focus as there is a gap in the literature of less focus on creative physical activities such as dance.

2.1 Exploration of Body Movement Educational Needs of BLV People

Research on physical education and sports for BLV people [20, 38, 40, 48, 66] indicates that the participation of BLV people in body movement activities is less compared to sighted populations due to multiple barriers. Some barriers identified are travelling to physical education programs [48, 59], reduced opportunities for social interactions [18, 44, 48], safety concerns [18, 47], lack of inclusive educational programs [14] and not having high quality instructors [18]. For instance, Mycock and Molnár [74] provide knowledge on the lived experience of the first author as a coach transferring from the dominant coaching paradigm (the ableist model) to coaching blind football that requires additional attention to numerous challenges such as the significant gap in key skill sets, the additional care, negotiating infrastructural shortcomings, developing different coaching styles and strategies along with assuming a support role. Studies in physical activities of BLV people identify the use of software and computing devices as a positive factor and facilitator for the participation of BLV people [48, 65]. It is recommended for research in access technology [98] to explore the problems and needs first, increasing the likelihood of developing technology that addresses a valid user need [86]. Few studies, however, have investigated the needs of BLV people when designing technology-driven solutions for body movement participation, either initiating an exploration study [47, 88] or brainstorming ideas [87, 107].

2.2 Body Movement Educational Practices for BLV People

The general ways of transferring motor skills are using pictorials, verbal descriptions and mirroring the teacher [1, 8]. Duggar [24] explains how body movement is taught in a visual nature, stating, "Do it like this" when it is meant to be developing a kinesthetic sense which involves bodily movement and awareness, by relying on our own body experiences to understand information. Seham and Yeo [96] state the importance of not relying on visual cues when teaching blind people: "When teaching the blind, however, the initial concept of each step, pose, position, or movement must be conveyed without reliance on visual cues". A primary non-visual technique of teaching body movement to BLV people is verbal instructions [38, 95]. However, adapting the right terminology to suit BLV students requires investment in time and skill of the teachers [114], which can be quite challenging.

Physical interactions or touch demonstrations are generally used as a complementary teaching technique with verbal descriptions when training BLV people in body movement [38, 77, 83]. **Physical interaction** can take the form of physical guidance or tactile modeling. **Physical guidance** is the use of physical assistance by an instructor to convey the feel, rhythm, and motion which includes physical placement of the student's body part. In contrast, **tactile modeling** is the inspection by a student of a demonstrator by touch. Both of these methods have inherent benefits and challenges. Physical guidance can lead to misinterpretation and might not be the option for students who are sensitive to touch [77]. A similar problem exists with tactile modeling in which the personal space of the instructor or a peer is intruded upon and might not be the most appropriate technique [27].

2.3 Representations of Body Movement for BLV people

Traditional methods for non-visual access to information include verbal description and raised line drawings. Audio description of events for people who are BLV is most commonly used for theatre, television and movies but also extends to sporting events [32, 99]. Raised line drawings are recommended as the best way for people who are blind or have low vision to access and understand diagrams with spatial information [15, 57, 79]. However, guidelines for the design of raised line drawings assume that they will be based on static images [15, 26, 79]. Another approach is the use of tactile graphics [52] or models with movable parts, such as Fleximan by Hungry Fingers (Figure 1a, [64]) and manipulative figures of Andy Dreams by (Figure 1b, Claire Garrett [34]). Furthermore, some tools, such as refreshable graphics displays [41, 55], have been evaluated in representing body movement concepts (Figure 2). For instance, Holloway and colleagues [41] compared the representation of body poses on a refreshable graphics display and an equivalent tactile graphic, finding that the graphic display was more successful. In

Figure 1: Examples of traditional approaches to conveying movement with movable parts: (a) Fleximan figure with movable parts (Picture credit: Boguslaw Marek, Hungry Fingers) (b) Manipulative Andy Dreams figures with a tactile illustration of the same pose behind it. (Picture credit: childsPly Vision by Claire Garrett).

addition, sound is commonly used to provide information about positioning in space for sports, for instance, with bells inside balls [38] for activities such as goalball and blind cricket.

Figure 2: A refreshable graphics display, Graphiti displaying a Tai Chi human pose.

2.4 Technological Support for Body Movement Participation of BLV people

Many accessibility technologies based studies have aimed to assist BLV people in body movement to improve spatial awareness without relying on sighted guides [3, 21, 23, 29, 61, 73, 80, 81, 87, 90, 91] and to enhance performance [51, 68, 69, 85, 107]. Miura, Watanabe and colleagues [69, 107] implemented a training application for goalball players to predict the direction, height, and distance of an approaching ball using binaural sound. However, fewer have been designed to support learning or understanding how to perform a body movement activity [22, 89]. Dias and colleagues [22] have developed a solution combining a web-based interface and a commercially available body tracking device, to provide the students with pre-recorded dance instructions and synthesized audio feedback for understanding body poses and directional cues. The need for understanding different actions in engaging body movement is a clear need which was also pointed out by Morelli and colleagues [71] who experimented with sensory substitution of exergames such as the VI-bowling. They share that they verbally instructed how to play the games but found that "some children did not know or understand how to swing a tennis racket" while some have developed "completely new ways to swing their racket". This leads to the need for exploring what challenges exist when BLV people are learning body movement and correct techniques.

With the Covid-19 pandemic, there was a trend in supporting online education, including physical and mental health-focused activities such as exercise programs and yoga [16, 17, 67]. Some support BLV people to adapt and engage virtually in different body movement categories such as sports [53, 71], exergames [72] and yoga exercises [89]. Both pre-pandemic [69, 89] and recent post-pandemic [22, 107] studies have attempted to support training or learning body movement remotely. Few have explored whether those solutions are practical and sustainable to use at home beyond a lab environment. Rector and colleagues [89] designed an exergame aiming for long-term engagement rather than short-term use in a lab setting for blind yoga learners at home. However, it is unclear, and there is a need for further understanding of how BLV people learn body movement with the recent and rapid development of online content and remote learning tools.

Some studies have consulted teachers and instructors of the relevant sport or activity. However, few have collaborated from the initial design or exploration stages [21, 22, 89]. For instance, Cooper and colleagues [21] investigated multiple electronic prototype designs uncovering necessary characteristics of an audible-based hockey puck through iterative design based on feedback from blind hockey players and their coaches. Little work has considered the interaction between the student and the teacher as a research aim [2, 62]. Aggravi and colleagues [2] designed a haptic assistive bracelet that allows ski instructors to provide directional guidance

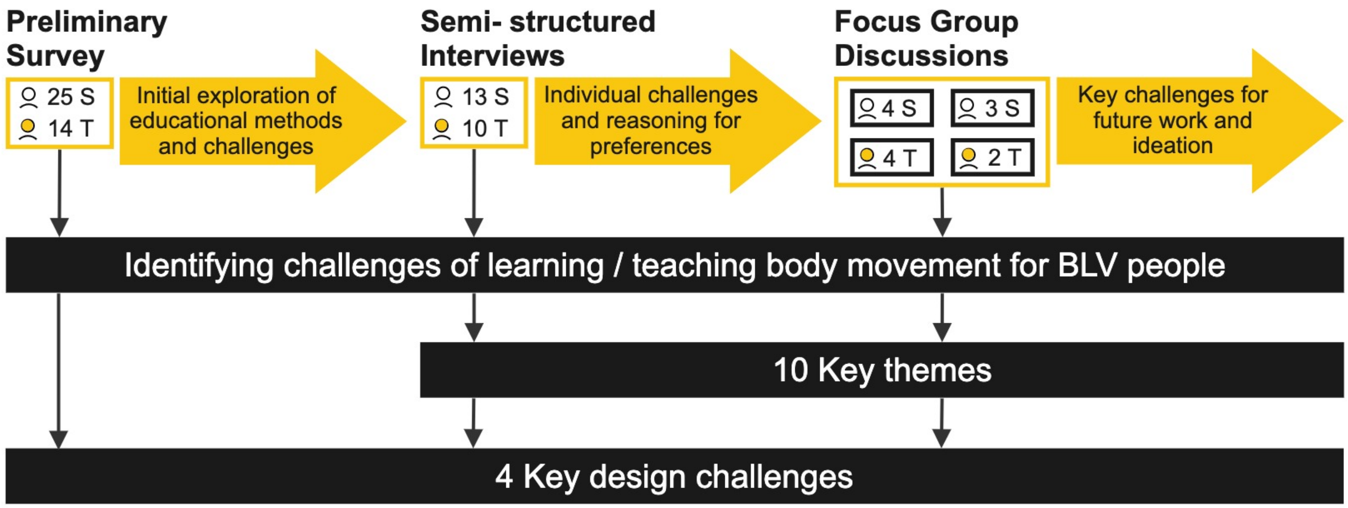

Figure 3: The methodology and the key findings of the process. Participant categories of BLV students are denoted by 'S' and teachers by 'T' in yellow boxes. Input for the next stage in yellow arrows. All three stages contribute to identifying challenges in learning and teaching body movement. Analysis from interviews and focus groups contributes to identifying ten key themes. Finally, all findings contribute to deriving four key design challenges.

to their students. However, it is unclear what challenges are experienced by the teachers and how these designs can help them to educate BLV people.

While prior research has explored various technological approaches to improve access to participation in body movement activities, it still remains unknown how BLV people and their teachers adopt these methods. Further, most of the body movement educational practices remain separate from the technologies research space, and there is less evidence of initial explorations conducted involving people with lived experiences in understanding their challenges. Thus, our study explores an in-depth understanding of the challenges and opportunities of educating BLV people, offering insights into how technology can facilitate their teachers to deliver a better outcome.

3 METHODOLOGY

3.1 Methodological Overview

With the aim of addressing the research questions and considering the gaps in the literature, we conducted a series of data collection with (1) BLV adult students interested in learning body movement ('S'); and (2) teachers who have experience in teaching body movement to BLV people ('T') (Figure 3). We first conducted a short survey to get a broad insight, and then we conducted interviews and focus groups to obtain a deeper understanding of key issues.

3.2 Preliminary Survey

3.2.1 Instrument. The survey began with obtaining demographic information, including frequently used assistive technologies. We considered 'body movement' as recreational physical activities such as sports, yoga, exercise and dance while allowing participants to state a variety of physical activities they engage in. We then asked BLV students about their interests in body movement and methods of accessing body movement education. In the survey for teachers, we asked about their expertise in body movement and the methods they use in teaching body movement for BLV people. In both surveys, we asked them to list challenges they experienced when learning or teaching body movement.

3.2.2 Recruitment and Participants. The surveys were distributed online using Google Forms. They were tested for accessibility, and keyboard shortcuts were provided. The survey link was shared through an approved participant pool, social media, listservs [2] and organisations that educate BLV people on body movement. A total of 25 people responded to the BLV student's survey and a total of 14 to the teacher's survey (Figure 3). The median age range of the BLV students was reported to be 35-44, and for teachers, it was 45-54. The majority of BLV students (64%) and teachers (78%) were from Australia. Some BLV students (32%) were from the United States, and one from Canada. The remaining teachers were from the United Kingdom, Egypt and Netherlands. A majority of the BLV students self-identified as female (68%), 20% as male and 8% as non-binary. Similarly, the teachers mostly self-identified as female (57%), 28% as male and 14% as non-binary. Of the BLV students, the blindness condition was self-reported as 44% totally blind, 48% as legally blind (not totally blind but qualifies for government aid [78]), and two as low vision stating that they have "peripheral vision loss" and "left eye cataract right eye no vision". One of the teachers self-reported as legally blind, and they had acquired blindness before age 30. 44% of the BLV students are congenitally blind. For the remaining students, the average onset of blindness was 16 years (SD = 14.5). 40% of BLV students considered themselves either up-to-date with new technology or early adopters. Most teachers (64%) considered themselves up-to-date with new technology.

[2] Listservs are electronic mailing list systems that enable group communication and facilitate the distribution of information among subscribers with shared interests.

Attribute	BLV Students	Teachers
Age	25 - 75 and above, Median: 45-54	26 - 75, Median: 45-54
Gender	F (9), M (3), N (1)	F (5), M (4), N (1)
Country	Australia (9), USA (4)	Australia (8), Egypt (1), Netherlands (1)
Blindness	Totally blind (7), Legally blind (5), Low vision (1)	Legally blind (1)
Onset	Congenitally blind (6), later in life (7)	Later in life (1)
Tech adoption	Need support (3), Up-to-date (5), Early adopter (5)	Need support (3), Up-to-date (6), Early adopter (1)
Body Movement	Dance (8), Sports (9), Martial arts (8), Yoga (6), Circus (1)	Dance (6), Sports (4), Physical education (3), O&M (1)

Table 1: Demographic information of interview participants. O&M stands for Orientation and Mobility. Gender is listed by referring to female as 'F', male as 'M' and non-binary as 'N'.

3.2.3 Analysis. As our intention was to gain high-level insight, we have provided a descriptive summary of the data collected from the surveys in section 4.2. We summarised the responses provided as the interests of BLV students and the expertise of teachers. We then compared the current educational methods across the two participant groups: BLV students and teachers. Finally, we have briefly listed the challenges shared by both participant groups.

3.3 Semi-structured Interviews

3.3.1 Study Procedure. We conducted semi-structured interviews to expand the understanding gained from the surveys with BLV students and teachers. The interviews were intended to understand their individual experiences in learning or teaching body movement, including any reasoning behind the teaching method selections teachers adopt to provide access to body movement, what challenges are encountered, and the motivations of BLV people behind their preferences. Participants were asked if the Covid-19 impacted their learning or teaching body movement and their opinions on using technology-based methods. We questioned the teachers on their experiences and reasoning regarding the different modes of conducting classes for BLV people. For instance, how they feel about conducting BLV-specific classes vs inclusive classes and in-person vs online classes. Then teachers were asked what techniques and tools they use and in what situations.

3.3.2 Recruitment and Participants. Thirteen BLV students and ten teachers who consented to join follow-up discussions were recruited for the interviews (Figure 3). All interviews were conducted by the same researcher, scheduled for the convenience of the participants. Refer to Table 5 and Table 6 for the individual demographic information of the interview participants, which also includes the expertise of teachers. The median age range of both BLV students and teachers was 45-54 (Table 1). The vast majority of BLV students (69%) and teachers (80%) were from Australia. A majority of BLV students self-identified as female (69%), 23% as male and 7% as non-binary. Half of the teachers self-identified as female, 40% as male and 10% as non-binary. Of the BLV students, the blindness condition was self-reported as 53% totally blind, 38% as legally blind, and 7% as low vision. 46% of the BLV students are congenitally blind, and the average onset of blindness was 20 years (SD = 16.61) for the remaining students. One BLV student has been legally blind since birth and has become totally blind when eight. One of the teachers self-reported as legally blind, and they had acquired blindness before age 30.

3.3.3 Analysis. The interviews were conducted online or by phone for around 45-60 minutes. All interviews were audio-recorded and transcribed. The transcripts of all participants were analyzed together and subjected to a thematic analysis based on a qualitative approach using both inductive and deductive coding in several rounds [93]. The transcripts were inductively coded in the first coding round to identify challenges, learning methods and teaching techniques. Deductively, furthermore, codes were identified such as 'physical contact', 'support from another', and 'safety considerations'. Three researchers discussed and grouped the identified challenges under four key themes of body movement elements. Then those themes and challenges were subjected to further discussion with focus groups of the same participant pool since they were frequently mentioned in the interviews and required further understanding.

Next, two independent researchers validated codes in the initial round by randomly sampling transcripts. They coded five random transcripts (three transcripts of BLV students and two transcripts of teachers) and discussed any discrepancies. Based on those discussions, a final codebook was formed, and one researcher recoded all interview transcripts. A final validation round was conducted by another researcher examining a subset of the transcripts. They confirmed all coded parts were correct.

3.4 Focus Groups

The focus group discussions with BLV students and teachers aimed to confirm further and understand the challenges identified from the interviews. In addition, we intended to identify their priorities among those challenges.

3.4.1 Study Procedure. One researcher facilitated all focus groups, and another researcher observed the process. The focus group discussions were conducted online for around 90-120 minutes.

Each focus group comprised two discussion rounds. In the first round, participants were provided with a summary of the challenges discovered from the interviews (section 3.3.3) with a focus on body movement elements (body awareness, spatial awareness, etc.). Participants were asked to share their opinion on those challenges, select what they believed was important to be addressed first and if there was anything further to be considered. Finally, in the second round, the facilitator summarised what was discussed,

Attribute	Students FG1	Students FG2	Teachers FG1	Teachers FG2
Gender	F (3), M (1)	F (1), M (1), N (1)	F (2), M (2)	F (1), N (1)
Blindness	Totally blind (1), Legally bind (2), Low vision (1)	Totally blind (2), Legally bind (1)	Legally blind (1)	-
Onset	Congenitally blind (1), later in life (3)	Congenitally blind (3)	Later in life (1)	-
Body Movement	Dance (3), Sports (4), Martial arts (3), Yoga (3)	Dance (1), Sports (2), Martial arts (1), Yoga (1), Circus (1)	Dance (2), Sports (2), Physical education (1), O&M (1)	Dance (1), Sports (1), Physical education (1)

Table 2: Demographic information of focus group (FG) participants. O&M stands for Orientation and Mobility. Gender is listed by referring to female as 'F', male as 'M' and non-binary as 'N'. All participants were from Australia.

confirming the notes taken and asked the participants again to express what should be prioritised based on the overall session.

3.4.2 Recruitment and Participants. The interview participants who provided consent and who were able to join in a common time frame were invited for collaborative focus group discussions. One participant who could not join the interview also joined the focus groups responding to a previous invitation. The focus group discussions were conducted separately with the BLV students and teachers to encourage open discussion and avoid potential power dynamics. Two focus group discussions were conducted with BLV students, with one having four participants and another with three participants (Table 2). Similarly, for teachers, two focus group discussions were conducted, with one having four participants and another with two participants.

3.4.3 Analysis. All focus group discussions were audio-recorded and transcribed. Then the four scripts were coded using the same codebook derived from the interview analysis. However, a new category code was introduced to capture responses relating to the prioritisation of challenges, which had not emerged earlier and was a key element of the focus groups.

4 RESULTS

4.1 Overview

In this section, we first present the survey findings, including the intentions set for the interviews. We then report on emergent themes from both interviews and focus group studies. These are presented together owing to two reasons: first, the focus groups predominantly expanded upon topics from the interviews; and second, we observed repetition of some experiences shared by the participants. However, findings from the focus groups confirmed many insights from the interviews and identified key priorities, which are noted as appropriate.

4.2 Survey

4.2.1 Interests and Expertise. Interestingly, the majority of BLV student respondents (n=20) were interested in learning dance. Other interests were sports (n=16), martial arts (n=11), yoga (n=9) and other types of activities (n=11), including tai chi, circus, bowling, and kayaking. One respondent specifically listed dance as an activity they stopped learning. Another respondent who did not select dance stated in the survey about dance:

> "I feel hesitant to participate in case I embarrass myself by moving the wrong way"

The teachers who responded to the survey mainly work as dance teachers (n=8) and experts in sports (n=6), while some work as physical education teachers (n=3) and a few are experts in yoga, and orientation and mobility. Most teachers have experience educating BLV children and adults (n=10), while four teachers have only taught adults, and two teachers have taught only children.

4.2.2 Current Learning or Teaching Methods. (Table 3) summarises the learning methods used by BLV students, along with the methods used by teachers. All BLV students responded (n=25) they learn body movement by verbal instructions provided by a teacher or someone they know. The next most frequently used learning method was physical guidance by an instructor (n=18). The remaining methods of access were tactile modelling (n=9), videos (n=13), and written descriptions (n=3).

All teachers (n=14) verbally instruct their BLV students, while most of them use physical guidance and tactile modelling (n=12), except for two teachers who conduct online sessions. Sound-based tools such as whistles, drums, and clapping are being equipped by some teachers to guide their BLV students (n=10). Some of them mentioned how they used sound-based techniques, like "African drums to cue movement", and "clapping to guide students if, for instance, they are running across the room". Four teachers share educational content through instructional videos and use 3D models. Three teachers use instructional images. One teacher commented about using images, "Images not so useful in a group setting either and would have to be shown up very close".

Although some teachers use sound-based tools (n=10), 3D models (n=4), and instructional images (n=3), none of the BLV students experienced such tools. Three BLV students shared the use of written descriptions in the survey, but none of the teachers mentioned their use of them. Half of the blind (n=7) and low vision (n=6) students make use of videos to learn body movement. However, only four teachers stated the use of videos as educational materials.

4.2.3 Challenges of Learning Body Movement. Table 4 summarises the primary challenges in learning body movement, as identified

Suggested learning/ teaching method	Teachers (n=14)	BLV (n=25)	T (n=11)	L (n=14)
Verbal instructions	14	25	11	14
Physical guidance	12	18	9	9
Tactile Modelling	12	9	5	4
Sound-based tools	10	0	0	0
Videos	4	13	7	6
3D models	4	0	0	0
Instructional images	3	0	0	0
Written descriptions	-	3	1	2

Table 3: Body movement educational methods used by BLV students and teachers. 'T' represents totally blind students, 'L' represents legally blind and low vision students

by BLV students. The majority of the BLV student respondents (n=18) find it challenging to learn body movement since they don't receive feedback. Many BLV students (n=15) believe instructions alone are insufficient to understand body movement. Some BLV students find difficulties in following floor markings and boundaries (n=14), following objects played with (n=13) and moving with others (n=10). Regarding learning materials in general, such as videos, 15 students responded that they do not have access to them in accessible formats, while 12 responded to not having descriptions of those learning materials, and nine students found it difficult to learn without tangible materials to touch. Two students do not prefer physical contact. One student interested in martial arts elaborated in the survey how physical contact is important for a congenitally blind person and the impact of having more people to support:

> "Being totally blind from birth, I have not had the experience of seeing others do a physical activity, so even mentioning, for example, that the movement is similar to holding a baseball bat doesn't mean much to me. The very best way to learn is to have the instructor make the move on me and then for me to practice the move with two others so that there is someone to observe my movements on my partner"

When BLV students were provided with a list of challenges in the survey, teachers were provided with a free text field input because the teacher's perspective has received less prior exploration (section 2.1). Some of the challenges listed by teachers were around verbal instructions such as "Difficult to communicate subtleties of movement/style", "It took me a while to remember I had to say everything, so much more talking than in an ordinary class where you... rely on what the students can see to fill in the gaps", or "Sometimes I struggle with what words to use to describe something to someone who has never had the vision to see movement". One respondent mentioned that BLV people's lack of body awareness is "problems with body plan, body awareness and body idea". Another respondent shared, "Poor spatial awareness, lack of body concepts, poor balance, fear of moving in space".

4.2.4 Summary. BLV students who responded to the survey showed interest in learning a variety of body movements. However, there were activities reported that they have stopped or wish to learn in future, such as dance which needs further understanding as to why. There was a mixture of experiences among teachers in educating BLV children and adults that could be insightful if there was any difference in educating them. Instructions and physical guidance were the most used methods. However, there were some indications from BLV students on the insufficiency of instructions for understanding body movement and a few not preferring physical contact. Further, some teachers indicated difficulties in communicating movement. Both BLV students and teachers indicated problems in spatial and body awareness. There are some mismatches in some tools used by teachers and the exposure by the BLV students to those tools. Thus, we conducted interviews to understand the reasoning behind the survey responses.

4.3 Interviews and Focus Groups

Results from both interviews and focus group discussions are provided here. Ten themes emerged from the analysis of the transcripts of both studies. Table 7, presented in the Appendix, provides an overview of themes that emerged in both or either of the studies. Overall the themes that emerged are related to practices in teaching BLV people, challenges, motivations and body movement elements. However, owing to the inherent interrelatedness of these themes, we have opted to present them as distinct entities, rather than grouping them under overarching categories. Please note that the participants are referenced using the prefix to represent the student ('S') or teacher ('T'), the number to represent the participant ID and the suffix to represent the study ('I' for the interview or 'F' for focus groups). For example, S3I refers to a BLV student who participated in the interviews and S3F refers to the same student but a statement made in the focus groups.

4.3.1 Verbal Instructions. All BLV students expect verbal instructions to be detailed and specific. S9I explained, "The teachers don't say I'm standing at a 45-degree angle with my feet a foot apart. They don't say that stuff". Some BLV students (S2I, S3I, S4I, S14F) prefer instructions supported with metaphors, such as "bend your arms and wave them like you're a bird flapping their wings" (S3I) or "move your body like a blade of grass, or a tree waving in the wind" (S14F). Three teachers mentioned that they use metaphors (T1I, T4I, T5I). However, three BLV students raised the issue that congenitally blind people might not understand or relate to the visual aspect of such metaphors (S5I, S6I, S7I). S5I shared, "They asked for a movement. For what movement will you do for the colour yellow ... I've never seen yellow. I have no idea".

From the teachers' perspective, some (T1I, T5I, T9I) found it difficult to explain the details and subtleties of body movement, which they could conveniently demonstrate visually. T1I recalls one of their experiences:

> "I tried to write down the movement and I remember looking back on it, I could not make sense of it. The main reason is, there are too many variables. In human movement, it's very complex... Words don't do it justice."

One teacher (T5I) tried to empathise by using different techniques of their own such as closed eyes instructions. S11I shared their experience of learning from such a teacher. However, a low vision teacher T9I expressed that even if they have the empathy of

Challenge	BLV students (n=25)
I do not get feedback on whether I am doing the pose correctly	18
Instructions alone are not enough for understanding human movements	15
I do not have access to learning materials such as videos in accessible formats	15
I cannot learn with the speed of the instructor	15
I cannot follow floor markings or where to move in the space	14
I cannot follow objects used in the activity such as a ball when playing football	13
Descriptions are not provided in learning materials	12
Verbal instruction does not provide feedback on emotions, body language and other aspects	10
I cannot follow where to move in the space with other students	10
It is difficult to learn without tangible materials to touch	9
I do not like physical touching	2

Table 4: Challenges of learning body movement for BLV students

having a blindness condition, she struggles in instructing her BLV students.

> "I can understand like, what they're thinking or what they're going through, and then sometimes it's not helpful. I still struggle, because people's vision is different."

S11I stated that vocabulary is another contributing factor to the complexity of verbal instructions. They stated that the use of different terms to refer to the same or similar body poses and movements by different teachers is a challenge for BLV students. Further, they propose if there was a tactile dictionary of poses, it would be beneficial for cross-disciplines.

It was stated by several BLV participants (S1I, S2I, S4I, S7I) that they appreciate the understanding of how a body movement or a pose should feel and are not limited to how it should visually look like. S2I stated, "describing how something should feel, instead of how something should look, is the best way to go".

Two BLV participants (S2I, S3I) pointed out the effort required to concentrate on listening to the instructions. S3I stated "most people get that double bit of information, the hearing and the scene. So I have to be dependent on the hearing". Similarly, S2I shared "I felt like I really had to concentrate and then listen to everything the teacher was saying". Further adding to the focus on one medium of information (hearing instructions), T8I explained the need for additional modalities to support verbal instructions compared to sighted students who get double information based on verbal instructions and visual demonstrations,

> "...if it was perfect, then that's all we would ever give our sighted students [who] always rely on visual and verbal. So we can't expect our blind students to just rely on verbal they need something else they need something tactile, and or audio feedback, of how it sounds when they're doing the movement."

Four other teachers (T3I, T5I, T9I, T10I) and two BLV students (S9I, S11I) expressed similar opinions.

4.3.2 Physical Contact and Guidance. According to many teachers (T2I, T3I, T4I, T5I, T6I, T7I T8I, T9I, T10I) and BLV students (S2I, S5I, S6I, S8I, S9I, S10I, S11I), teaching a particular body movement supported with physical contact-based instructions was expressed as a beneficial technique. S8I explained how his martial arts instructor has been helpful through a hands-on approach. Four teachers indicated how physical contact is supportive in teaching dance (T4I, T5I) and is inherent in some dance styles (T3I, T10I). From a sports and physical education perspective, T8I explained that teaching a particular body movement for the first time is effective through the support of physical guidance and T6I commented that physical contact is beneficial in providing feedback,

> "Professionally, it's a fantastic tool, because it can give you an instant way of getting a student feedback and giving them information about what the movement looks like, and how a complex movement might look and how much force to put into something, how fast to do something."

There are, however, several factors contributing to the avoidance of physical contact in teaching body movement. Some BLV students do not prefer physical contact (S11I, S13I) and some have different preferences depending on the person and how it takes place (S2I, S3I, S4I, S7I). It matters to them whether they are comfortable with the teacher. Another BLV student (S11I) preferred to bring a support worker or a friend who they are familiar with,

> "I took one of my really good friends along, she was my support worker. I was really comfortable with her life, so she could touch me if she needed to. I'm a little bit less confident having other people touch me. I would probably try to avoid it."

Another preference factor is how physical contact takes place. For instance, whether it should be light touch or a strong one. IS2 stated it might be acceptable for a light touch but T4I stated that they learned the touch should be firm. Consent plays a major role in physical interactions and it has an impact on body movement teaching. Requesting consent is subjective to the person's preferences. During one of the focus group discussions, this was debated as one might need a consent request just once as S14F mentioned,"I'm more than happy for you to come in touch me and guide me in any way. You don't even have to tap me to do it. Just do it". However, another participant in the same focus group (S3F) expected consent-seeking each time the teacher approaches them within a class, "I'd be different...I do want you to tell me in advance... each time I like them to tell me they're gonna do it". Another factor for consideration in physical guidance is the health impact caused by the pandemic (S2I, S3I, S10I, T2I).

4.3.3 Tools Supporting Teaching.

Some teachers are equipped with tools in addition to verbal instructions and physical guidance. Three teachers (T3I, T6I, T8I) mentioned the use of figures such as dolls and wooden human models. T8I described the use of such figures,

> "let's get my 3D model. They get their hands on the model. So this is where your foot was. And this is what your foot did. So that's one way they can get feedback is from me, recreating their movement through a tactile model."

A similar idea was proposed by S13I on the use of flexible 3D structures that can bend well similar to the human body , "I'm wondering whether what really would help would be rubber man, sort of figures that you could put into the position and so that they can be felt and then replicated".

Some teachers use sound-based tools such as balls with sound and squeaky toys (T7I, T8I, T9I). Recording the sound of movement to let BLV students listen is another strategy used by T8I to provide feedback.

> "Every very low vision or blind student who really relies on sound will have memorised that sound. They have to be good at that because that's one of the ways that they make sense of the world is by understanding sound...when you're kicking your legs for a flutter kick in the pool, a good flutter kick, sounds a certain way...It's a video for those students, it's their way of playing back things."

Some teachers use wall-to-wall chords (T6I, T7I) and tactile diagrams (T8I) to indicate boundaries, floor patterns and, in sports, team members' positions. T8I explained that the game is halted in some situations to explain to the players which is challenging and impacts the flow of the game.

4.3.4 Community Knowledge Sharing and Practice.

Some professional bodies exist to support teachers to cater to BLV students' needs, such as in improving orientation and mobility and in contexts such as schools as shared by some teachers (T2I, T6I, T7I and T8I). T6I suggested that it would be beneficial if there were consultants who could support teachers who have BLV students in their educational programs. In the focus groups, it was observed that there is a need for community sharing on how they can accommodate BLV students. For instance, T5F explained their novice experiences in teaching BLV people,

> "I've never spoken to anybody who's ever taught anybody blind...it's just good to have somebody who's, you know, on the same wavelength and understands what you are doing"

To which, then T8F responded that they could connect them with others who have similar experiences. T6F and T9F appreciated and pointed out the importance of understanding the perspectives of different body movement experts. S6F shared that they teach and share their experiences with other blind people.

4.3.5 Spatial and Social Awareness.

Both BLV students and teachers raised challenges specific to spatial awareness. One that emerged several times is how BLV students find it challenging to position themselves in the class space with respect to others (S1I, S2I, S5I, S7I, S8I, S10I, S11I). For instance, S5I stated that one reason for bringing in a support worker is to ensure that others in the class are not being affected by them. Six participants echoed the same challenge in three focus groups (S6F, S11F, S13F, T2F, T5F, T8F). However, two teachers shared their experiences of addressing it. An instructor with expertise in team sports (T9F) explained a strategy on how team players act as sound beacons supporting each other to locate themselves. T2F termed it as 'beacon wayfinding' in Orientation and Mobility terms. T8F discussed about two types of movement skills in sports, open and closed, and the impact of environmental awareness:

> "In sport, we talk a lot about closed skills versus open skills. Closed skill is a skill that basically you're trying to do to absolute perfection because the skill never changes. Whereas when you think about an open skill, that's a skill you must modify, depending on the environment and other players. The impact of that environment on learning is really it's not a small one"

Further needs described were being aware of their self-position while making turning moves (S13I, T5I) and having better contrast in the environments where students with low vision learn and practice these lessons (S2I, S11I, S1F, S14F). Safety was another spatial-related concern contributing to the lack of confidence to participate in physical activities from younger ages, as described by many teachers (T3I, T5I, T6I, T7I, T8I, T10I). T6F questioned the researchers and other focus group participants whether technology can support in improving safety,

> "Would any technology to enhance safety be of benefit because I know quite a lot of vision impaired students are reluctant participants because of safety. An example might be fear of colliding with another person when playing cricket."

4.3.6 Support system.

BLV students find it useful to have a support person when participating in group sessions as shared by them and observed by teachers (S1I, S3I, S4I, S5I, S6I, S7I, S9I, S10I, S11I, S12I, T4I, T6I, T9I, T10I). Support people or sometimes peers and friends become guidance for BLV people in learning and accessing body movement by either describing what the teacher is performing or being the person next to them so that a low vision person can copy what they are doing, as S11I explains,

> "I look to the support workers to sort of mirror what they were doing, or sort of provide some guidance. As I was moving through the space, making sure that I was doing it, even not too badly "

It was pointed out that the skill or experience of the support person can impact their learning. For instance, S3I mentioned that their support person was knowledgeable and helpful in learning a fast-paced environment. However, if the support person is not familiar with the particular body movement, it can result in learning inaccuracies, as S8I explained.

4.3.7 Motivations. Among the motivations for learning body movement, the most frequently stated was social interaction (S1I, S3I, S4I, S6I, S7I, S9I, S10I, S12I). S10I explained their motivation to be included,

> "I'm just not very good at doing things at home. I don't have the motivation. I want to be a part of it, what I want is social interaction with other people."

Some prefer attending a class with their companions who have inspired them, as IS1 mentioned when sharing about experimenting with different body movements, "So I went with a friend... I started doing it online in lockdown just for fun with a friend who invited me...". S3I stated how they intend to meet beyond BLV people by attending programs other than BLV-specific ones, "I don't just want to have contact with people who are blind and visually impaired. I don't want to be kind of so narrow that I don't have contact with other people".

4.3.8 Online Learning and Technologies. With the pandemic situation, rapid changes in learning environments were witnessed. This had an impact on body movement education and resulted in opportunities and challenges. S1I explained how her online teacher "doesn't know how to set it up so she can see us" performing while they are teaching. Another BLV student (S13I) explained how she made use of selfie sticks and mobile technologies to ensure she is visible to her teacher. The availability of accessible online content for a variety of sports was stated as a priority by S8I,

> "I think the most important thing is that there needs to be more online content for people with vision impairment with instructional content, on how to perform different sports. So, there need to be instructional videos on blind tennis, blind soccer."

S2I (who has low vision and having further vision loss) pointed out that they had become used to accessing the same video as they don't find it as easy as other sighted people who can make use of their vision,

> "I guess the difference between me and someone who sighted is. I couldn't just scroll through Youtube and think, Oh, that one that's good. I'll do that one. I've got to kind of just do the ones that I'm used to "

Five BLV students (S4I, S5I, S6I, S7I, S9I) pointed out the lack of feedback as a key drawback of online learning including online classes and online content for BLV people. S5I identified the lack of feedback as the reason for not using audio described online videos, "[I have] No idea if I'm actually doing things correctly" and stated they appreciate it if learning at home is made accessible, " if you could get haptic feedback, and work on things in your own home with other described videos and stuff, that can be really useful".

4.3.9 Body Awareness. Having the right body posture was said to be a key challenge, as prioritised in the focus groups. It was implied as a priority by nine participants in three focus groups. T10F shared their experience that they have to teach posture to many new BLV dancers, " we find that quite a lot of the dancers, when they first come to us may not actually know how to walk properly...". Body awareness in terms of kinesthetics and proprioception (the ability of the body to sense the position, movement, and orientation of its own limbs and joints without relying on visual cues) was discussed by several teachers (T5I, T7I, T8I, T9I and T10I). T8F explained how posture is affected by kinesthetic awareness,

> " postural awareness and general body awareness, particularly for people who are congenitally blind, is very difficult because they don't have what all of us have, kinesthetic awareness. That kinesthetic awareness isn't supported by my eyes, looking at my hand, saying, Okay, this is where my hand is"

T5I who is experienced with teaching BLV adults, stated that BLV people have good proprioception skills. However, T7I, who is more experienced with instructing BLV children talked about the lack of proprioception of congenitally blind students.

Another key challenge discussed along with posture was body balance. It was prioritised by four participants in three focus groups. Some dance teachers (T1I and T10I) avoid teaching movements such as turning around and jumping to BLV students as they impact body balance. S10 echoed their avoidance of any movement impacting balance in both interview and focus group discussion, "I just ignore all the balance stuff, I can't do any of it". However, S2I had a different view on body balance where they believe body balance is about feeling rather than seeing. Based on a similar opinion of not relying on vision to balance body, T5F shared their experiences of how they apply their understanding of teaching BLV people to teach sighted students, encouraging them to focus on balance with closed eyes. T2F expressed that a cane might be provided if the person needs a third point of contact on the ground to balance themselves. However, if the balance is caused by reasons that are not vision-related they would recommend meeting a physiotherapist. In the same focus group, T9F expressed how body balance is challenging when other elements of body movement come into play, such as weight transfer and speed.

4.3.10 Movement Qualities. Some BLV students expressed that understanding weight transfer (S6F and S13F) is a challenge and that it is intertwined with balance. T9F explained how they find it challenging to teach blind students how much force or how fluid the movement should be. A key challenge was discussed and prioritised in one focus group (by three teachers) on how to teach fluidity of movement by combining speed and application of force. T6F raised the problem by explaining,

> "for example, in an efficient running stride, you might have students mapping you as in feeling your upper and lower leg as you talk about the movement, but they're feeling it in slow motion, they're not feeling it in actual time... wondering how to bridge those gaps and make it more fluid. "

In the same discussion, another teacher (T2F) suggested an idea to address this problem of fluidity teaching, "I wonder if it's possible to develop something that gives like a positive audio cue when the body's getting it right".

In the interviews, BLV people expressed that they were comfortable understanding the timing of movement, and it was not discussed as a problem. However, it was raised and stated (without prompting) otherwise in two focus groups by two BLV students and three teachers. S10F shared, something that I think I struggle with is timing. So if it's something that has a movement, that is repetitive, like steps in a dance, like, the actual timing of the moves is often lacking". S7I shared an idea of how wearables can be integrated to learn body movement, including timing and speed of it, "if you're trying to do fast punches with taekwondo or something, maybe having it set up so... it could be speeding up to do it [tapping] quicker or slowing down".

4.3.11 Summary. The ten themes described above provide insights into the key challenges and needs of BLV students and teachers. There are several expectations of BLV students on verbal instructions. However, teachers find it challenging to rely solely on verbal instructions and require other techniques and tools supporting in addition to verbal instructions. While physical guidance plays a supporting role in educating BLV students, there are some indications of hindrances to physical contact. Key problematic areas of teaching BLV students were around body awareness, spatial awareness and movement qualities. BLV students indicated the value of online learning. However, they shared some concerns and needs on accessing online content. Community sharing of expertise was suggested in the interviews and was observed in practice through focus groups. The BLV students expressed the need for human interactions in terms of support and social engagement.

5 DISCUSSION

In this section, we discuss the summary of the insights gained from all three studies and identify four key design challenges (Figure 4). Each key challenge is defined based on our findings and is linked to past literature providing implications for technological opportunities.

5.1 Design Challenge 1: Representation of Body Movement to Support Verbal Instructions

One of the major concerns repeatedly voiced by BLV people is the lack of detailed body movement instructions. However, describing a body movement purely in verbal terms is a complex task for teachers. This indicates design challenge 1: exploring supplementary mediums for verbal instructions supporting teachers to convey body movement details that could also act as a second mode of confirmation for BLV students.

A compounding problem, pointed out by a teacher with low vision, is that there are diverse experiences of blindness. Some teachers try to empathise by using different techniques such as closed eyes instructions (section 4.3.1). There is potential to explore the solution space on evolving use of vision simulation [36, 104] based on virtual reality [110] and wearable displays [6, 113]. However, it is important to be mindful of problems with relating to a BLV person without lived experiences [10, 31].

Some teachers and studies [89] suggest the use of metaphors when describing movement, which was a strength for low vision students and blind students who lost their vision in later stages of life. However, congenitally blind students find it difficult to relate to the visual aspects of such metaphors (section 4.3.1). Furthermore, it was pointed out that there are vocabulary issues when teachers refer to the same pose by different names. Several teachers and some BLV students shared that BLV people require a second mode of confirmation, which sighted students get through visual stimuli. As some BLV students suggested, a collection of body movement representations similar to a dictionary in tactile format [84] such as 3D printed moving graphics [52], static or dynamic tactile graphics on refreshable displays [37, 41] could be potential solutions to explore. For instance, Kim and Yeh [52] created 3D printed movable tactile pictures for BLV children where they suggest using a movable set of components that can be added to 3D prints to represent the motion and understand the kinetic experiences, which can be further explored to represent human body movement.

Another instance of using tactile graphics is the exploration conducted by Holloway and colleagues [41] that indicates the potential of using refreshable graphics displays to represent body movement concepts. Similarly, Kobayashi and Tatsumi [55] have explored refreshable tactile graphics to represent Floor-Volleyball motion to BLV players, and their results indicate a complication of showing the shape of players. While both works highlight some limitations in representing whole body movement, refreshable tactile displays demonstrate other strategies for representing shapes and poses in tactile graphics. Furthermore, some research has been conducted on using tactile materials to support orientation and mobility concepts [82] but little research considering details of body movement and contextualised physical activities such as dance and sports [19, 55].

5.2 Design Challenge 2: Supporting Feedback and Improving Kinesthetic Awareness

A majority of teachers make use of physical contact or tactile instructions in addition to verbal instructions when adjusting posture and providing feedback to BLV people [77]. However, there are several social factors that can inhibit the use of physical contact (section 4.3.2). Furthermore, a major challenge highlighted by teachers is that they find it difficult to explain the fluidity of movement, even through physical manipulations (section 4.3.10). By fluidity, they mean kinesthetic awareness of how fast the movement should be, how much force to apply and from which part of the body it should be applied or supposed to be feeling. Thus, this imposes two design challenges. One is to explore how we can imitate the benefits of physical contact. The second is to explore how the fluidity of body movement can be communicated to BLV people.

Some teachers specialising in training children and younger adults use manipulative human models such as dolls and figures to provide tactile feedback (section 4.3.3). Literature indicates the wide use of 3D models for educational purposes [30], medical science contexts for understanding human anatomy [75, 111], and some early experiments of using humanoids [58, 92] with little to no research on the use of 3D human models in the physical education contexts for BLV people. Further, some teachers use and recommend sound-based tools to convey the fluidity of movement and provide feedback. The preliminary survey reported much less use of sound-based tools by teachers (section 4.2.2), with the tools being mostly low or not technology-oriented (whistles, beeping balls, clapping). However, as pointed out in interviews (section 4.3.3), using the recorded sounds of movement to provide feedback to BLV students is a strength. None of the adult BLV participants reported being

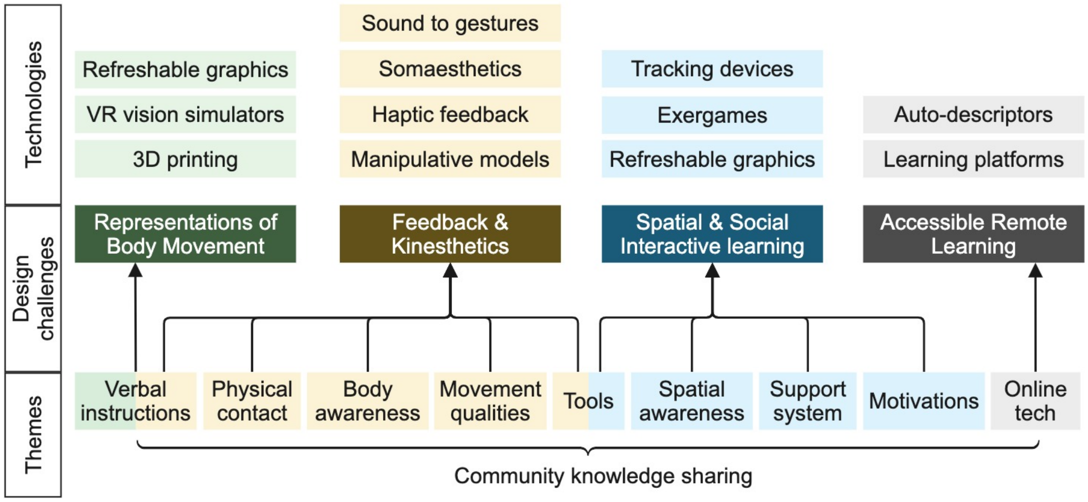

Figure 4: Mapping of themes from results to key design challenges and technology implications.

exposed to the use of 3D model figures and sound-based tools. These findings motivate us to investigate how manipulative human models [34] and sound-based tools [11, 22, 46, 63, 85, 91] can be used as a technique by the wider teaching community to provide feedback and represent body fluidity for BLV learners. For instance, our findings highlight the importance of considering fluidity of movement, especially in goalball throws, beyond understanding the direction of a moving ball [69, 107].

An insight shared by BLV participants is that they valued knowing how and where they are supposed to feel when engaging in a certain body movement (section 4.3.1). Similarly, teachers shared the importance of kinesthetic awareness impacting body posture and balance (section 4.3.9). This inspires us to explore how concepts such as somatic pedagogy [96] and somaesthetics can facilitate in conveying the sensory experiences of body movement [45]. For instance, Seham and Yeo [96] state, "Although these methods have not been empirically studied nor specifically designed for people with visual impairment, somatic pedagogy presents viable, non-visual movement communication strategies compatible with the learning needs of blind students". Further, imitating physical contact or touch simulation to improve kinesthetic awareness can be explored in terms of haptics-based ideas [100]. Haptic feedback-based solutions have been explored to understand whole-body navigation and particular limb movement [42]. However, there is less research conducted on fine-tuning the quality of movement with the intention of teaching body movement and supporting the connection between the teacher and BLV learner [2, 62]. For instance, Malik and colleagues [62] presented a novel technology design by developing an algorithm for a sensor-based mat to support blind people to be in sync in a group-based aerobics class. While this supports tracking the time of the steps, which is a key aspect of quality of movement, there is an underlying assumption that the learner is familiar with the exercises. They have also explored reactive verbal feedback, which is a key need our studies identify as well. It can be beneficial to explore the potential of other kinds of feedback methods, consider the movement of different parts of the body, and focus on other spatial arrangements beyond a confined area of mat space.

5.3 Design Challenge 3: Supporting Spatial and Social Interactive Body Movement Learning

Orientation and Mobility training improve spatial awareness and navigation of BLV people. Additionally, support workers and other companions provide assistance to BLV people. One major concern raised on spatial understanding was reduced awareness of others in the space and their movement (section 4.3.5), which we present as a design challenge to be addressed. This was also presented as a reason contributing to safety and confidence. Another insight from the findings was that social interaction is a key motivation (section 4.3.7) for BLV people to participate in body movement activities and attend in-person classes. Interestingly, BLV people showed interest in social engagement and were less concerned about independence when participating in body movement. This insight shows the potential for another design challenge to explore the combination of the needs of BLV people for social awareness and social interaction.

There are some attempts by teachers to represent and train to respond to game changes, such as player positions using tools such as magnetic boards (section 4.3.3). Refreshable tactile graphics [41, 55] could also be potential solutions. However, those require the game to be paused in the middle or be moved away from the court, interfering with the spontaneity of the activity. Research has widely explored supporting BLV people in navigating outdoor [5, 43, 102], or indoor spaces [4, 49, 54, 82], and object tracking [21, 39, 90]. Furthermore, there are studies supporting directional guidance as advised by instructors [2]. However, the needs raised from this study are focused towards the awareness of the movement of other people in a space and in a fast-moving pace.

Many studies involving different technologies have aimed at real-time person tracking [33, 103, 109] including collocated person tracking in virtual reality [108] supporting collision avoidance [94].

Some studies have explored person tracking aiming for BLV people in applications such as tracking people standing in lines [56], and tracking for distance maintenance in a crowd due to Covid-19 [97]. However, there is less evidence of the exploration in the context of body movement learning spaces. Al-Zayer, Folmer and colleagues [3, 29] conducted a Wizard of Oz study investigating how the sound cues of drones can support blind runners to stay in line in an indoor space without obstacles and the need for a sighted guide. While safety is a key spatial concern that our studies identified, attention is also needed on ways to be aware of themselves in a space shared with many others. Furthermore, support from another person was indicated as a strength, especially in improving human interactions. Solutions addressing this need could result in supporting BLV people to engage in group-based body movements such as group sports and group dance performances, opening more avenues for inclusion. Further adding to the second design challenge, research has been explored on making physical play such as exergames accessible to address the needs of BLV people [35, 70–72]. However, a few such tools let BLV participants interact socially with others online, while the focus on in-person social interactions is minimal [9].

5.4 Design Challenge 4: Supporting Accessible Remote Learning

With the Covid-19 situation, people relied on remote learning programs to practice or learn body movement, which could also benefit BLV people to overcome various other barriers, including travelling and finding accessible in-person classes [48, 59]. However, remote learning is said to be lacking feedback even more than in-person activities (section 4.3.8). Feedback-focused research studies conducted for accessible remote learning of physical activities are limited [22, 89]. For instance, Dias and colleagues [22] suggest an asynchronous platform that provides auditory feedback when a student attempts a pre-recorded dance lesson, and Rector and colleagues [89] have designed a solution providing auditory confirmation for blind yoga learners at home. The research community could explore accessible synchronous learning strategies and experiment with other modalities, including haptics, as suggested by our participants (section 4.3.8). Exergames such as VI-bowling [72] and VI-tennis [71] have adapted sports games by converting visual cues to audio and haptic feedback. Although improving energy expenditure has been the primary aim of these studies, tools and techniques introduced in these works have further potential to be explored for motor learning. For instance, VI-bowling [72] uses a technique that can point out a direction to a player, tactile dowsing, which could be explored for accessible learning of physical activities.

Furthermore, there is a need to focus on supporting the creation of accessible online content, especially videos with descriptions (section 4.3.8). Several studies have focused on video accessibility, such as providing automatic descriptions [28, 106], including humans in the loop with machine learning descriptions [112], collaborating with sighted writers [76] or BLV writers [50], querying supported bots 'InfoBot's [13]. These studies indicate the descriptions of characters and actions. However, for the objective of learning body movement, further studies are essential to inquire about the needs of BLV people when deriving descriptions to create accessible online content. Additionally, as pointed out by our participants, searching options should also be considered when considering access to online content.

6 LIMITATIONS AND FUTURE WORK

In our work, we intended to understand the challenges of people with lived experiences in terms of our participants. Thus, we aimed for teachers that have experience in teaching BLV students. A further contribution is possible if the accessibility research community can explore and design solutions considering both expert and novice teachers or teachers with no prior experience in educating BLV people. Our findings do not represent the needs of all BLV people, and we encourage researchers to explore further barriers to body movement when designing technological solutions. Additionally, there could be an impact on the results based on the varied experience of teachers, including their length of experience, the number of BLV students they taught and the blindness variations of their students. Furthermore, we intended the focus group participants to prioritise key challenges by selecting and ranking them. Although participants suggested some as key challenges, they found it difficult to choose one above the other and implied that these challenges are dependent on the variation of blindness. However, having both individual perspectives through interviews and group perspectives through interactive focus group discussions contributed to the identification of validated insights.

7 CONCLUSION

In this paper, we describe the findings of a preliminary survey study, semi-structured interviews involving thirteen BLV students and ten teachers, and four focus group studies involving seven BLV students and six teachers to understand their current body movement educational techniques and related challenges. Our work identifies ten insightful themes and four key design challenges to be addressed, proposing potential areas of solutions extending assistive technologies research on accessible representations, kinesthetic awareness, spatial awareness, and remote learning support for body movement education of BLV people. Finally, we encourage the assistive technologies community to co-design potential solutions to these identified challenges promoting the quality of life of BLV people and supporting the teachers in the provision of inclusive education.

REFERENCES

[1] Jack A. Adams. 1987. Historical review and appraisal of research on the learning, retention, and transfer of human motor skills. *Psychological Bulletin* 101, 1 (Jan. 1987), 41–74. https://doi.org/10.1037/0033-2909.101.1.41

[2] Marco Aggravi, Gionata Salvietti, and Domenico Prattichizzo. 2016. Haptic Assistive Bracelets for Blind Skier Guidance. In *Proceedings of the 7th Augmented Human International Conference 2016 (AH '16)*. Association for Computing Machinery, New York, NY, USA, 1–4. https://doi.org/10.1145/2875194.2875249

[3] Majed Al Zayer, Sam Tregillus, Jiwan Bhandari, Dave Feil-Seifer, and Eelke Folmer. 2016. Exploring the Use of a Drone to Guide Blind Runners. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (Reno, Nevada, USA) *(ASSETS '16)*. Association for Computing Machinery, New York, NY, USA, 263–264. https://doi.org/10.1145/2982142.2982204

[4] Tomohiro Amemiya and Hisashi Sugiyama. 2010. Orienting Kinesthetically: A Haptic Handheld Wayfinder for People with Visual Impairments. *ACM Transactions on Accessible Computing* 3, 2 (Nov. 2010), 6:1–6:23. https://doi.org/10.1145/1857920.1857923

[5] Cédric Anthierens, Didier Groux, and Vincent Hugel. 2018. Sensory navigation guide for visually impaired sea kayakers. *Journal of Field Robotics* 35, 5 (2018), 732–747.

[6] Halim Cagri Ates, Alexander Fiannaca, and Eelke Folmer. 2015. Immersive Simulation of Visual Impairments Using a Wearable See-through Display. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (Stanford, California, USA) *(TEI '15)*. Association for Computing Machinery, New York, NY, USA, 225–228. https://doi.org/10.1145/2677199.2680551

[7] Maryam Bandukda, Catherine Holloway, Aneesha Singh, Giulia Barbareschi, and Nadia Berthouze. 2021. Opportunities for Supporting Self-Efficacy Through Orientation & Mobility Training Technologies for Blind and Partially Sighted People. In *Proceedings of the 23rd International ACM SIGACCESS Conference on Computers and Accessibility* (Virtual Event, USA) *(ASSETS '21)*. Association for Computing Machinery, New York, NY, USA, Article 32, 13 pages. https://doi.org/10.1145/3441852.3471224

[8] Albert Bandura. 1997. *Self-efficacy: the exercise of control*. W.H. Freeman, New York.

[9] Tiziana Battistin, Nadir Dalla Pozza, Silvia Trentin, Giovanni Volpin, Andrea Franceschini, and Antonio Rodà. 2023. Co-designed mini-games for children with visual impairment: a pilot study on their usability. *Multimedia Tools and Applications* 82, 4 (Feb. 2023), 5291–5313. https://doi.org/10.1007/s11042-022-13665-7

[10] Cynthia L. Bennett and Daniela K. Rosner. 2019. The Promise of Empathy: Design, Disability, and Knowing the "Other". In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3290605.3300528

[11] Andreas Bergsland and Robert Wechsler. 2015. Composing Interactive Dance Pieces for the MotionComposer, a Device for Persons with Disabilities. In *Proceedings of the International Conference on New Interfaces for Musical Expression* (Baton Rouge, Louisiana, USA) *(NIME 2015)*. The School of Music and the Center for Computation and Technology (CCT), Louisiana State University, Baton Rouge, Louisiana, USA, 20–23.

[12] Faine Bisset. 2016. *The lived experience of university students with visual impairments and their sighted partners' participation in inclusive social ballroom dance*. Ph. D. Dissertation. Stellenbosch: Stellenbosch University.

[13] Aditya Bodi, Pooyan Fazli, Shasta Ihorn, Yue-Ting Siu, Andrew T Scott, Lothar Narins, Yash Kant, Abhishek Das, and Ilmi Yoon. 2021. Automated Video Description for Blind and Low Vision Users. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA '21)*. Association for Computing Machinery, New York, NY, USA, 1–7. https://doi.org/10.1145/3411763.3451810

[14] Boni Boswell, Bomna Ko, and Seok Yoon. 2022. Experiences and motivations of dancers with and without disabilities in inclusive dance. *Sport, Education and Society* (03 2022), 1–14. https://doi.org/10.1080/13573322.2022.2047018

[15] Braille Authority of North America (BANA). 2010. *Guidelines and Standards for Tactile Graphics*. The Braille Authority of North America, USA. http://www.brailleauthority.org/tg/

[16] Jacinta Brinsley, Matthew Smout, and Kade Davison. 2021. Satisfaction with Online Versus In-Person Yoga During COVID-19. *The Journal of Alternative and Complementary Medicine* 27, 10 (Oct. 2021), 893–896. https://doi.org/10.1089/acm.2021.0062 Publisher: Mary Ann Liebert, Inc., publishers.

[17] Phoebe Brosnan, Maya Nauphal, and Martha C. Tompson. 2021. Acceptability and feasibility of the online delivery of hatha yoga: A systematic review of the literature. *Complementary Therapies in Medicine* 60 (Aug. 2021), 102742. https://doi.org/10.1016/j.ctim.2021.102742

[18] Audun Brunes, Eli Krokstad, and Liv Berit Augestad. 2017. How to succeed? Physical activity for individuals who are blind. *British Journal of Visual Impairment* 35, 3 (2017), 264–274.

[19] Matthew Butler, Leona Holloway, Samuel Reinders, Cagatay Goncu, and Kim Marriott. 2021. Technology Developments in Touch-Based Accessible Graphics: A Systematic Review of Research 2010-2020. In *CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3411764.3445207

[20] Michele Capella-McDonnall. 2007. The need for health promotion for adults who are visually impaired. *Journal of Visual Impairment & Blindness* 101, 3 (2007), 133–145. https://doi.org/10.1177/0145482X0710100302

[21] Triston Cooper, Heather Lai, and Jenna Gorlewicz. 2022. Do You Hear What I Hear: The Balancing Act of Designing an Electronic Hockey Puck for Playing Hockey Non-Visually. *ACM Transactions on Accessible Computing* 15, 1 (March 2022), 4:1–4:29. https://doi.org/10.1145/3507660

[22] José Rodrigues Dias, Rui Penha, Leonel Morgado, Pedro Alves da Veiga, Elizabeth Simão Carvalho, and Adérito Fernandes-Marcos. 2019. Tele-Media-Art:Feasibility Tests of Web-Based Dance Education for the Blind Using Kinect and Sound Synthesis of Motion. *International Journal of Technology and Human Interaction (IJTHI)* 15, 2 (2019), 11–28. https://doi.org/10.4018/IJTHI.2019040102 Publisher: IGI Global.

[23] Qicheng Ding, Jiangtao Gong, Jingwei Sun, Penghui Xu, Liuxin Zhang, Qianying Wang, and Yu Zhang. 2019. HeliCoach: A Drone-Based System Supporting Orientation and Mobility Training for the Visually Impaired. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–6. https://doi.org/10.1145/3290607.3312763

[24] Margaret P. Duggar. 1968. What Can Dance Be to Someone who Cannot See? *Journal of Health, Physical Education, Recreation* 39, 5 (May 1968), 28–30. https://doi.org/10.1080/00221473.1968.10611719

[25] Josée Duquette, Mathieu Douville, Khatoune Temisjian, Laura Steinmander, Guylaine Cataford, Tiiu Poldma, Jacques Gresset, Rosa Pinniger, Rhonda Brown, Jacqueline Simpson, et al. 2012. *Tango Through Different Eyes: Adapting Tango Classes for Seniors with Visual Impairment*. INLB, Longueuil Canada.

[26] Polly K. Edman. 1992. *Tactile Graphics*. AFB Press, Arlington, VA, USA.

[27] Ferhat Esatbeyoglu, Tn Kirk, and Justin A Haegele. 2021. "Like I'm flying": Capoeira dance experiences of youth with visual impairments. *British Journal of Visual Impairment* (Nov. 2021), 026461962110597. https://doi.org/10.1177/02646196211059756

[28] Itamar Rocha Filho, Felipe Honorato, J. Wallace Lucena, J. Pedro Teixeira, and Tiago Maritan. 2021. An Approach for Automatic Description of Characters for Blind People. In *Proceedings of the Brazilian Symposium on Multimedia and the Web (WebMedia '21)*. Association for Computing Machinery, New York, NY, USA, 53–56. https://doi.org/10.1145/3470482.3479617

[29] Eelke Folmer. 2015. Exploring the use of an aerial robot to guide blind runners. *ACM SIGACCESS Accessibility and Computing* 112 (July 2015), 3–7. https://doi.org/10.1145/2809915.2809916

[30] S. Ford and T. Minshall. 2019. Where and how 3D printing is used in teaching and education. *Additive Manufacturing* 25 (2019), 131–150. https://doi.org/10.1016/j.addma.2018.10.028

[31] Sally French. 1992. Simulation Exercises in Disability Awareness Training: A Critique. *Disability, Handicap & Society* 7, 3 (Jan. 1992), 257–266. https://doi.org/10.1080/02674649266780261

[32] Louise Fryer. 2016. *An Introduction to Audio Description: A practical guide*. Routledge.

[33] Wei Gai, Meng Qi, Lu Wang, Chenglei Yang, Juan Liu, Yulong Bian, Gerard De Melo, Shijun Liu, and Xiangxu Meng. 2019. Catch the Shadow: Person Tracking Under Occlusion with a Single RGB-D Camera. In *2019 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI)*. 413–418. https://doi.org/10.1109/SmartWorld-UIC-ATC-SCALCOM-IOP-SCI.2019.00114

[34] Claire Garrett. [n. d.]. Andy Dreams. https://childsply.wixsite.com/catalogue/product-page/andy-dreams

[35] Barbara Gasperetti, Matthew Milford, Danielle Blanchard, Stephen P. Yang, Lauren Lieberman, and John T. Foley. 2010. Dance Dance Revolution and EyeToy Kinetic Modifications for Youths with Visual Impairments. *Journal of Physical Education, Recreation & Dance* 81, 4 (April 2010), 15–55. https://doi.org/10.1080/07303084.2010.10598459

[36] Joy Goodman-Deane, Patrick M. Langdon, P. John Clarkson, Nicholas HM Caldwell, and Ahmed M. Sarhan. 2007. Equipping Designers by Simulating the Effects of Visual and Hearing Impairments. In *Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility* (Tempe, Arizona, USA) *(Assets '07)*. Association for Computing Machinery, New York, NY, USA, 241–242. https://doi.org/10.1145/1296843.1296892

[37] Darren Guinness, Annika Muehlbradt, Daniel Szafir, and Shaun K. Kane. 2019. RoboGraphics: Dynamic Tactile Graphics Powered by Mobile Robots. In *Proceedings of the 21st International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '19)*. Association for Computing Machinery, New York, NY, USA, 318–328. https://doi.org/10.1145/3308561.3353804

[38] Justin A Haegele and Lauren J Lieberman. 2019. Movement and visual impairment: Research and practice. In *The Routledge handbook of visual impairment*. Routledge, 189–201.

[39] Liang He, Ruolin Wang, and Xuhai Xu. 2020. PneuFetch: Supporting Blind and Visually Impaired People to Fetch Nearby Objects via Light Haptic Cues. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–9. https://doi.org/10.1145/3334480.3383095

[40] Elizabeth A. Holbrook, Jennifer L. Caputo, Tara L. Perry, Dana K. Fuller, and Don W. Morgan. 2009. Physical Activity, Body Composition, and Perceived Quality of Life of Adults with Visual Impairments. *Journal of Visual Impairment & Blindness* 103, 1 (Jan. 2009), 17–29. https://doi.org/10.1177/0145482X0910300104

[41] Leona Holloway, Swamy Ananthanarayan, Matthew Butler, Madhuka Thisuri De Silva, Kirsten Ellis, Cagatay Goncu, Kate Stephens, and Kim Marriott. 2022. Animations at Your Fingertips: Using a Refreshable Tactile Display to Convey Motion Graphics for People who are Blind or have Low Vision. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '22)*. Association for Computing Machinery, New York, NY, USA, 1–16.

https://doi.org/10.1145/3517428.3544797

[42] Jonggi Hong, Alisha Pradhan, Jon E. Froehlich, and Leah Findlater. 2017. Evaluating Wrist-Based Haptic Feedback for Non-Visual Target Finding and Path Tracing on a 2D Surface. In *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS ’17)*. Association for Computing Machinery, New York, NY, USA, 210–219. https://doi.org/10.1145/3132525.3132538

[43] Stephan Huber, Anastasia Alieva, and Aaron Lutz. 2022. Vibrotactile Navigation for Visually Impaired People. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility* (Athens, Greece) *(ASSETS ’22)*. Association for Computing Machinery, New York, NY, USA, Article 86, 4 pages. https://doi.org/10.1145/3517428.3550387

[44] Elisabeth Hästbacka, Mikael Nygård, and Fredrica Nyqvist. 2016. Barriers and facilitators to societal participation of people with disabilities: A scoping review of studies concerning European countries. *Alter* 10, 3 (July 2016), 201–220. https://doi.org/10.1016/j.alter.2016.02.002

[45] Kristina Höök, Steve Benford, Paul Tennent, Vasiliki Tsaknaki, Miquel Alfaras, Juan Martinez Avila, Christine Li, Joseph Marshall, Claudia Daudén Roquet, Pedro Sanches, Anna Ståhl, Muhammad Umair, Charles Windlin, and Feng Zhou. 2021. Unpacking Non-Dualistic Design: The Soma Design Case. *ACM Transactions on Computer-Human Interaction* 28, 6 (Dec. 2021), 1–36. https://doi.org/10.1145/3462448

[46] Alon Ilsar and Gail Kenning. 2020. Inclusive improvisation through sound and movement mapping: from DMI to ADMI. In *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS ’20)*. Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/3373625.3416988

[47] Gesu India, Mohit Jain, and Manohar Swaminathan. 2021. Understanding Motivations and Barriers to Exercise Among People with Blindness in India. In *Human-Computer Interaction – INTERACT 2021 (Lecture Notes in Computer Science)*, Carmelo Ardito, Rosa Lanzilotti, Alessio Malizia, Helen Petrie, Antonio Piccinno, Giuseppe Desolda, and Kori Inkpen (Eds.). Springer International Publishing, Cham, 444–454. https://doi.org/10.1007/978-3-030-85623-6_27

[48] Eva A. Jaarsma, Rienk Dekker, Steven A. Koopmans, Pieter U. Dijkstra, and Jan H. B. Geertzen. 2014. Barriers to and facilitators of sports participation in people with visual impairments. *Adapted physical activity quarterly: APAQ* 31, 3 (July 2014), 240–264. https://doi.org/10.1123/2013-0119

[49] Myounghoon Jeon, Nazneen Nazneen, Ozum Akanser, Abner Ayala-Acevedo, and Bruce Walker. 2012. "Listen2dRoom": helping blind individuals understand room layouts. In *CHI ’12 Extended Abstracts on Human Factors in Computing Systems (CHI EA ’12)*. Association for Computing Machinery, New York, NY, USA, 1577–1582. https://doi.org/10.1145/2212776.2223675

[50] Lucy Jiang and Richard Ladner. 2022. Co-Designing Systems to Support Blind and Low Vision Audio Description Writers. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS ’22)*. Association for Computing Machinery, New York, NY, USA, 1–3. https://doi.org/10.1145/3517428.3550394

[51] Luiz Alberto Queiroz Cordovil Júnior, Gabriel Tadayoshi Rodrigues Oka, Moisés Pereira Bastos, Renan Lima Baima, Nilton Cesar Ferst, Ana Carolina Oliveira Lima, Ana Isabel Martins, and Nelson Pacheco Rocha. 2022. Trajectory Correction for Visually Impaired Athletes on 100 m Paralympic Races. In *Comprehensible Science (Lecture Notes in Networks and Systems)*, Tatiana Antipova (Ed.). Springer International Publishing, Cham, 393–401. https://doi.org/10.1007/978-3-030-85799-8_33

[52] Jeeeun Kim and Tom Yeh. 2015. Toward 3D-Printed Movable Tactile Pictures for Children with Visual Impairments. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI ’15)*. Association for Computing Machinery, New York, NY, USA, 2815–2824. https://doi.org/10.1145/2702123.2702144

[53] Shin Kim, Kun-pyo Lee, and Tek-Jin Nam. 2016. Sonic-Badminton: Audio-Augmented Badminton Game for Blind People. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI EA ’16)*. Association for Computing Machinery, New York, NY, USA, 1922–1929. https://doi.org/10.1145/2851581.2892510

[54] Eunjeong Ko, Jin Sun Ju, and Eun Yi Kim. 2011. Situation-based indoor wayfinding system for the visually impaired. In *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility (ASSETS ’11)*. Association for Computing Machinery, New York, NY, USA, 35–42. https://doi.org/10.1145/2049536.2049545

[55] Makoto Kobayashi and Hisayuki Tatsumi. 2021. Floor-Volleyball Motion Feedback System for Visually Impaired Players. In *Proceedings of the 12th International Conference on Education Technology and Computers (ICETC ’20)*. Association for Computing Machinery, New York, NY, USA, 46–50. https://doi.org/10.1145/3436756.3437020

[56] Masaki Kuribayashi, Seita Kayukawa, Hironobu Takagi, Chieko Asakawa, and Shigeo Morishima. 2021. LineChaser: A Smartphone-Based Navigation System for Blind People to Stand in Lines. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI ’21)*. Association for Computing Machinery, New York, NY, USA, Article 33, 13 pages. https://doi.org/10.1145/3411764.3445451

[57] Steve Landau. 2013. An Interactive web-based tool for sorting textbook images prior to adaptation to accessible format: Year 1 Final Report. (2013). http://diagramcenter.org/decision-tree.html

[58] Matthieu Lapeyre, Pierre Rouanet, Jonathan Grizou, Steve Nguyen, Fabien Depraetre, Alexandre Le Falher, and Pierre-Yves Oudeyer. 2014. Poppy Project: Open-Source Fabrication of 3D Printed Humanoid Robot for Science, Education and Art. 6. https://hal.inria.fr/hal-01096338

[59] Miyoung Lee, Weimo Zhu, Elizabeth Ackley-Holbrook, Diana G. Brower, and Bryan McMurray. 2014. Calibration and validation of the Physical Activity Barrier Scale for persons who are blind or visually impaired. *Disability and Health Journal* 7, 3 (July 2014), 309–317. https://doi.org/10.1016/j.dhjo.2014.02.004

[60] Lauren J. Lieberman, Cathy Houston-Wilson, and Francis M. Kozub. 2002. Perceived Barriers to Including Students with Visual Impairments in General Physical Education. *Adapted Physical Activity Quarterly* 19, 3 (July 2002), 364–377. https://doi.org/10.1123/apaq.19.3.364

[61] Shelby K Long, Nicole D Karpinsky, Hilal Döner, and Jeremiah D Still. 2016. Using a mobile application to help visually impaired individuals explore the outdoors. In *Advances in Design for Inclusion: Proceedings of the AHFE 2016 International Conference on Design for Inclusion, July 27-31, 2016, Walt Disney World®, Florida, USA*. Springer, Springer, Cham, 213–223.

[62] Jeehan Malik, Mitchell Majure, Hana Gabrielle Rubio Bidon, Regan Lamoureux, and Kyle Rector. 2021. Increasing Access to Trainer-led Aerobic Exercise for People with Visual Impairments through a Sensor Mat System. In *Proceedings of the 23rd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS ’21)*. Association for Computing Machinery, New York, NY, USA, 1–4. https://doi.org/10.1145/3441852.3476557

[63] Marcella Mandanici and Antonio Rodà. 2020. Large-Scale Interactive Environments for Mobility Training and Experience Sharing of Blind Children. In *Technological Trends in Improved Mobility of the Visually Impaired*, Sara Paiva (Ed.). Springer International Publishing, Cham, 301–318. https://doi.org/10.1007/978-3-030-16450-8_12

[64] Bogusław Marek. 2011. *Playing and learning with Fleximan*. Retrieved April 26, 2023 from https://hungryfingers.com/fleximan.html

[65] José Marmeleira and Luis Laranjo. 2020. Physical activity for adults with visual impairments: Benefits, barriers, and intervention strategies. In *Movement and Visual Impairment*. Routledge, 115–130.

[66] José Marmeleira, Luis Laranjo, Olga Marques, and Catarina Pereira. 2014. Physical Activity Patterns in Adults Who Are Blind as Assessed by Accelerometry. *Adapted Physical Activity Quarterly* 31, 3 (July 2014), 283–296. https://doi.org/10.1123/apaq.2013-0039

[67] Daniel J. McDonough, Melina A. Helgeson, Wenxi Liu, and Zan Gao. 2022. Effects of a remote, YouTube-delivered exercise intervention on young adults’ physical activity, sedentary behavior, and sleep during the COVID-19 pandemic: Randomized controlled trial. *Journal of Sport and Health Science* 11, 2 (March 2022), 145–156. https://doi.org/10.1016/j.jshs.2021.07.009

[68] Takahiro Miura, Masaya Fujito, Masaki Matsuo, Masatsugu Sakajiri, Junji Onishi, and Tsukasa Ono. 2018. AcouSTTic: A training application of acoustic sense on Sound Table Tennis (STT). In *Computers Helping People with Special Needs: 16th International Conference, ICCHP 2018, Linz, Austria, July 11-13, 2018, Proceedings, Part II 16*. Springer, Springer, Cham, 3–11.

[69] Takahiro Miura, Shimpei Soga, Masaki Matsuo, Masatsugu Sakajiri, Junji Onishi, and Tsukasa Ono. 2018. GoalBaural: A Training Application for Goalball-related Aural Sense. In *Proceedings of the 9th Augmented Human International Conference (AH ’18)*. Association for Computing Machinery, New York, NY, USA, 1–5. https://doi.org/10.1145/3174910.3174916

[70] Anthony Morelli. 2010. Haptic/audio based exergaming for visually impaired individuals. *ACM SIGACCESS Accessibility and Computing* 96 (Jan. 2010), 50–53. https://doi.org/10.1145/1731849.1731859

[71] Tony Morelli, John Foley, Luis Columna, Lauren Lieberman, and Eelke Folmer. 2010. VI-Tennis: a vibrotactile/audio exergame for players who are visually impaired. In *Proceedings of the Fifth International Conference on the Foundations of Digital Games (FDG ’10)*. Association for Computing Machinery, New York, NY, USA, 147–154. https://doi.org/10.1145/1822348.1822368

[72] Tony Morelli, John Foley, and Eelke Folmer. 2010. Vi-bowling: a tactile spatial exergame for individuals with visual impairments. In *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility (ASSETS ’10)*. Association for Computing Machinery, New York, NY, USA, 179–186. https://doi.org/10.1145/1878803.1878836

[73] Annika Muehlbradt, Varsha Koushik, and Shaun K. Kane. 2017. Goby: A Wearable Swimming Aid for Blind Athletes. In *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS ’17)*. Association for Computing Machinery, New York, NY, USA, 377–378. https://doi.org/10.1145/3132525.3134822

[74] David Mycock and Gyozo Molnar. 2020. ’The blind leading the blind’-A reflection on coaching blind football. *European Journal of Adapted Physical Activity* 14, 3

(2020).
[75] Mallikarjuna N. Nadagouda, Vandita Rastogi, and Megan Ginn. 2020. A review on 3D printing techniques for medical applications. *Current Opinion in Chemical Engineering* 28 (June 2020), 152–157. https://doi.org/10.1016/j.coche.2020.05.007
[76] Rosiana Natalie, Jolene Loh, Huei Suen Tan, Joshua Tseng, Ian Luke Yi-Ren Chan, Ebrima H Jarjue, Hernisa Kacorri, and Kotaro Hara. 2021. The Efficacy of Collaborative Authoring of Video Scene Descriptions. In *Proceedings of the 23rd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '21)*. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3441852.3471201
[77] Megan O'Connell, Lauren J. Lieberman, and Susan Petersen. 2006. The use of Tactile Modeling and Physical Guidance as Instructional Strategies in Physical Activity for Children who are Blind. *Journal of Visual Impairment & Blindness* 100, 8 (Aug. 2006), 471–477. https://doi.org/10.1177/0145482X0610000804
[78] Australian Institute of Health and Welfare. 2009. (2 ed.). 141–145 pages.
[79] Round Table on Information Access for People with Print Disabilities Inc. 2022. *Guidelines for Producing Accessible Graphics*. Round Table on Information Access for People with Print Disabilities Inc.„ Pyrmont, NSW, Australia. https://printdisability.org/guidelines/graphics-2022/
[80] Jonathan Oommen, David Bews, Mohsen Sheikh Hassani, Yuu Ono, and James R. Green. 2018. A Wearable Electronic Swim Coach for Blind Athletes. In *2018 IEEE Life Sciences Conference (LSC)*. 219–222. https://doi.org/10.1109/LSC.2018.8572105
[81] Aparna Padman, Jisha D. Saiju, Prabitha Prasad, Sheethu Gopal, and P.P. Hema. 2020. Location Tracking for Blind Swimmers. In *2020 International Conference on Power Electronics and Renewable Energy Applications (PEREA)*. 1–5. https://doi.org/10.1109/PEREA51218.2020.9339790
[82] Dominika Palivcová, Miroslav Macík, and Zdeněk Míkovec. 2020. Interactive Tactile Map as a Tool for Building Spatial Knowledge of Visually Impaired Older Adults. In *CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1–9. https://doi.org/10.1145/3334480.3382912
[83] Steve Paxton, Anne Kilcoyne, and Kate Mount. 1993. On the Braille in the Body: An Account of the Touchdown Dance Integrated Workshops with the Visually Impaired and the Sighted. *Dance Research* 11, 1 (April 1993), 3–51. https://doi.org/10.2307/1290603
[84] Mahika Phutane, Julie Wright, Brenda Veronica Castro, Lei Shi, Simone R. Stern, Holly M. Lawson, and Shiri Azenkot. 2022. Tactile Materials in Practice: Understanding the Experiences of Teachers of the Visually Impaired. *ACM Trans. Access. Comput.* 15, 3, Article 17 (jul 2022), 34 pages. https://doi.org/10.1145/3508364
[85] Joseph Ramsay and Hyung Jin Chang. 2020. Body Pose Sonification for a View-Independent Auditory Aid to Blind Rock Climbers. In *2020 IEEE Winter Conference on Applications of Computer Vision (WACV)*. 3403–3410. https://doi.org/10.1109/WACV45572.2020.9093462 ISSN: 2642-9381.
[86] Kyle Rector. 2020. *Technological advances* (1 ed.). Routledge, 161–172.
[87] Kyle Rector, Rachel Bartlett, and Sean Mullan. 2018. Exploring Aural and Haptic Feedback for Visually Impaired People on a Track: A Wizard of Oz Study. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility* (Galway, Ireland) *(ASSETS '18)*. Association for Computing Machinery, New York, NY, USA, 295–306. https://doi.org/10.1145/3234695.3236345
[88] Kyle Rector, Lauren Milne, Richard E. Ladner, Batya Friedman, and Julie A. Kientz. 2015. Exploring the Opportunities and Challenges with Exercise Technologies for People who are Blind or Low-Vision. In *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility (ASSETS '15)*. Association for Computing Machinery, New York, NY, USA, 203–214. https://doi.org/10.1145/2700648.2809846
[89] Kyle Rector, Roger Vilardaga, Leo Lansky, Kellie Lu, Cynthia L. Bennett, Richard E. Ladner, and Julie A. Kientz. 2017. Design and Real-World Evaluation of Eyes-Free Yoga: An Exergame for Blind and Low-Vision Exercise. *ACM Transactions on Accessible Computing* 9, 4 (April 2017), 1–25. https://doi.org/10.1145/3022729
[90] Mike Richardson, Karin Petrini, and Michael Proulx. 2022. Climb-o-Vision: A Computer Vision Driven Sensory Substitution Device for Rock Climbing. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems (CHI EA '22)*. Association for Computing Machinery, New York, NY, USA, 1–7. https://doi.org/10.1145/3491101.3519680
[91] Masaaki Sadasue, Daichi Tagami, Sayan Sarcar, and Yoichi Ochiai. 2021. Blind-Badminton. In *Universal Access in Human-Computer Interaction. Access to Media, Learning and Assistive Environments (Lecture Notes in Computer Science)*, Margherita Antona and Constantine Stephanidis (Eds.). Springer International Publishing, Cham, 494–506. https://doi.org/10.1007/978-3-030-78095-1_36
[92] Jayesh Saini and Esyin Chew. 2022. The Role of 3D-Technologies in Humanoid Robotics: A Systematic Review for 3D-Printing in Modern Social Robots. In *Recent Trends in Mechatronics Towards Industry 4.0 (Lecture Notes in Electrical Engineering)*, Ahmad Fakhri Ab. Nasir, Ahmad Najmuddin Ibrahim, Ismayuzri Ishak, Nafrizuan Mat Yahya, Muhammad Aizzat Zakaria, and Anwar P. P. Abdul Majeed (Eds.). Springer, Singapore, 275–287. https://doi.org/10.1007/978-981-33-4597-3_26
[93] Johnny Saldaña. 2021. The coding manual for qualitative researchers. *The coding manual for qualitative researchers* (2021), 1–440.
[94] Anthony Scavarelli and Robert J. Teather. 2017. VR Collide! Comparing Collision-Avoidance Methods Between Co-Located Virtual Reality Users. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI EA '17)*. Association for Computing Machinery, New York, NY, USA, 2915–2921. https://doi.org/10.1145/3027063.3053180
[95] Jenny Seham. 2012. Dance partners: A model of inclusive arts education for children and teens with different abilities. *The intersection of arts education and special education: Exemplary programs and approaches* (2012), 81.
[96] Jenny Seham and Anna J. Yeo. 2015. Extending Our Vision: Access to Inclusive Dance Education for People with Visual Impairment. *Journal of Dance Education* 15, 3 (July 2015), 91–99. https://doi.org/10.1080/15290824.2015.1059940
[97] Samridha Shrestha, Daohan Lu, Hanlin Tian, Qiming Cao, Julie Liu, John-Ross Rizzo, William H Seiple, Maurizio Porfiri, and Yi Fang. 2020. Active crowd analysis for pandemic risk mitigation for blind or visually impaired persons. In *Computer Vision–ECCV 2020 Workshops: Glasgow, UK, August 23–28, 2020, Proceedings, Part IV 16*. Springer, 422–439.
[98] Yue-Ting Siu. 2019. Foundations and recommendations for research in access technology. In *The Routledge Handbook of Visual Impairment* (1 ed.), John Ravenscroft (Ed.). Routledge, Milton Park, Abingdon, Oxon ; New York, NY : Routledge, 2019. | Series: Routledge international handbooks, 205–219. https://doi.org/10.4324/9781315111353-14
[99] Joel Snyder. 2014. *The Visual Made Verbal: A Comprehensive Training Manual and Guide to the History and Applications of Audio Description.* American Council of the Blind. https://adp.acb.org/articles/TheVisualMadeVerbal.html
[100] Yoonji Song and Jiye Kim. 2015. Mingle: Wearable Devices for Enhancing Communications and Activities between the Blind and Ordinary People through a Waltz. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '15)*. Association for Computing Machinery, New York, NY, USA, 367–370. https://doi.org/10.1145/2702613.2725435
[101] Brooke E. Starkoff, Elizabeth K. Lenz, Lauren Lieberman, and John Foley. 2016. Sedentary behavior in adults with visual impairments. *Disability and Health Journal* 9, 4 (Oct. 2016), 609–615. https://doi.org/10.1016/j.dhjo.2016.05.005
[102] Saiganesh Swaminathan, Yellina Yim, Scott E Hudson, Cynthia L Bennett, and Patrick Carrington. 2021. From Tactile to NavTile: Opportunities and Challenges with Multi-Modal Feedback for Guiding Surfaces during Non-Visual Navigation. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3411764.3445716
[103] Sheng Tan, Linghan Zhang, Zi Wang, and Jie Yang. 2019. MultiTrack: Multi-User Tracking and Activity Recognition Using Commodity WiFi. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3290605.3300766
[104] Garreth W. Tigwell. 2021. Nuanced Perspectives Toward Disability Simulations from Digital Designers, Blind, Low Vision, and Color Blind People. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 378, 15 pages. https://doi.org/10.1145/3411764.3445620
[105] Wendy Timmons and John Ravenscroft. 2019. Using expressive movement and haptics to explore kinaesthetic empathy, aesthetic and physical literacy. In *The Routledge Handbook of Visual Impairment* (1 ed.), John Ravenscroft (Ed.). Routledge, Milton Park, Abingdon, Oxon ; New York, NY : Routledge, 2019. | Series: Routledge international handbooks, 275–287. https://doi.org/10.4324/9781315111353-18
[106] Yujia Wang, Wei Liang, Haikun Huang, Yongqi Zhang, Dingzeyu Li, and Lap-Fai Yu. 2021. Toward Automatic Audio Description Generation for Accessible Videos. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3411764.3445347
[107] Michiharu Watanabe, Takahiro Miura, Masaki Matsuo, Masatsugu Sakajiri, and Junji Onishi. 2022. GoalBaural-II: An Acoustic Virtual Reality Training Application for Goalball Players to Recognize Various Game Conditions. In *Computers Helping People with Special Needs (Lecture Notes in Computer Science)*, Klaus Miesenberger, Georgios Kouroupetroglou, Katerina Mavrou, Roberto Manduchi, Mario Covarrubias Rodriguez, and Petr Penáz (Eds.). Springer International Publishing, Cham, 79–88. https://doi.org/10.1007/978-3-031-08645-8_10
[108] Tim Weissker, Pauline Bimberg, and Bernd Froehlich. 2021. An Overview of Group Navigation in Multi-User Virtual Reality. In *2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. 363–369. https://doi.org/10.1109/VRW52623.2021.00073

[109] Chi-Jui Wu, Steven Houben, and Nicolai Marquardt. 2017. EagleSense: Tracking People and Devices in Interactive Spaces Using Real-Time Top-View Depth-Sensing. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 3929–3942. https://doi.org/10.1145/3025453.3025562

[110] Tina Yao, Soojeong Yoo, and Callum Parker. 2022. Evaluating Virtual Reality as a Tool for Empathic Modelling of Vision Impairment: Insights from a Simulated Public Interactive Display Experience. In *Proceedings of the 33rd Australian Conference on Human-Computer Interaction* (Melbourne, VIC, Australia) *(OzCHI '21)*. Association for Computing Machinery, New York, NY, USA, 190–197. https://doi.org/10.1145/3520495.3520519

[111] Zhen Ye, Aishe Dun, Hanming Jiang, Cuifang Nie, Shulian Zhao, Tao Wang, and Jing Zhai. 2020. The role of 3D printed models in the teaching of human anatomy: a systematic review and meta-analysis. *BMC Medical Education* 20, 1 (Sept. 2020), 335. https://doi.org/10.1186/s12909-020-02242-x

[112] Beste F. Yuksel, Soo Jung Kim, Seung Jung Jin, Joshua Junhee Lee, Pooyan Fazli, Umang Mathur, Vaishali Bisht, Ilmi Yoon, Yue-Ting Siu, and Joshua A. Miele. 2020. Increasing Video Accessibility for Visually Impaired Users with Human-in-the-Loop Machine Learning. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–9. https://doi.org/10.1145/3334480.3382821

[113] Qing Zhang, Giulia Barbareschi, Yifei Huang, Juling Li, Yun Suen Pai, Jamie Ward, and Kai Kunze. 2022. Seeing Our Blind Spots: Smart Glasses-Based Simulation to Increase Design Students' Awareness of Visual Impairment. In *Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology* (Bend, OR, USA) *(UIST '22)*. Association for Computing Machinery, New York, NY, USA, Article 42, 14 pages. https://doi.org/10.1145/3526113.3545687

[114] Michelle R. Zitomer. 2016. 'Dance Makes Me Happy': experiences of children with disabilities in elementary school dance education. *Research in Dance Education* 17, 3 (Sept. 2016), 218–234. https://doi.org/10.1080/14647893.2016.1223028

A INDIVIDUAL DEMOGRAPHIC INFORMATION OF INTERVIEW AND FOCUS GROUP PARTICIPANTS

ID	Age	Country	G	B	Onset	Tech Adoption	Body Movement	F
S1	45-54	Australia	F	L	Acquired before 20yrs	Need support	D,S,M,Y	Y
S2	35-44	USA	F	L	Congenitally blind	Up-to-date	D,Y	-
S3	55-64	Australia	F	L	Congenitally blind	Up-to-date	S,M,Y	Y
S4	65-74	USA	F	L	Acquired before 20yrs	Up-to-date	D,M,Y	-
S5	35-44	Australia	F	T	Congenitally blind	Early adopter	D,S	-
S6	55-64	Australia	M	T	Congenitally blind	Up-to-date	S,M	Y
S7	55-64	USA	F	T	Acquired before 20yrs	Need support	D,S,M	-
S8	35-44	Australia	M	L	Acquired before 10yrs	Up-to-date	S,M	-
S9	25-34	USA	F	T	Acquired before 10yrs	Early adopter	S,M	-
S10	45-54	Australia	M	T	Acquired before 40yrs	Early adopter	D,S,M	Y
S11	35-44	Australia	N	L	Congenitally blind	Early adopter	S,C	Y
S12	75-up	Australia	F	T	Acquired before 60yrs	Need support	D,Y	-
S13	55-64	Australia	F	T	Congenitally blind	Early adopter	D,Y	Y
S14*	45-54	Australia	F	L	Acquired before 30yrs	Early adopter	D,S,Y	Y

Table 5: Demographics and other information of BLV students participated in the interviews. 'Y' stands for participants who joined the focus group discussions (F). *S14 participated in focus group discussions only. Different body movement categories are identified as 'D' for dance, 'S' for sports, 'M' for martial arts, 'Y' for yoga, and 'C' for circus. Blindness (B) categories are referred by 'T' is for totally blind, and 'L' is for legally blind or low vision. Gender (G) is listed by referring to female as 'F', male as 'M' and non-binary as 'N'.

ID	Age	G	Expertise (type)	Expertise (style)	Expertise (yrs)	Taught (age)	Taught (#)	Tech Adoption	F
T1	35-44	F	D	West African dance	22	A	50	Up-to-date	-
T2	55-64	F	O&M	-	29	C,A	200-300	Need support	Y
T3	45-54	M	D	Tango	5	C,A	Many	Up-to-date	-
T4	25-34	F	D	Commercial Jazz	12	C,A	3	Up-to-date	-
T5	65-75	F	D	Ballet	10	A	Around 12	Up-to-date	Y
T6	45-54	M	D,S,PE	Many	25	C,A	80	Up-to-date	Y
T7	55-64	M	S,PE	Many	36	C	Around 100	Need support	-
T8	35-44	N	S,PE	Many	18	C,A	200	Early adopter	Y
T9*	25-34	F	S	Goalball	10	C,A	Unsure	Up-to-date	Y
T10	55-64	M	D	Ballroom	2	A	16	Need support	Y

Table 6: Demographics and other information of teachers who participated in the interviews. 'Y' stands for participants who joined the focus group discussions (F). Different body movement expertise categories are identified as 'D' for dance, 'S' for sports, 'PE' for physical education, and 'O&M' for Orientation and Mobility. Gender (G) is listed by referring to female as 'F', male as 'M' and non-binary as 'N'. 'C' indicates teachers who have taught children and 'A' who have taught adults. *All teachers are sighted except T9 is legally blind and acquired at before 30 years. All teachers are from Australia except for T3 from Egypt and T7 from the Netherlands.

B THEMES OF INTERVIEW AND FOCUS GROUP DISCUSSIONS ANALYSIS

Theme	Sub theme / code	I	S	T	F	S	T
Verbal instructions	Difficulties in explaining details	Y	Y	Y	Y	Y	Y
Verbal instructions	Relatable examples and counter argument	Y	Y	Y	Y	Y	-
Verbal instructions	Empathised teaching	Y	Y	Y	Y	-	-
Verbal instructions	Vocabulary needs	Y	Y	-	Y	Y	-
Verbal instructions	Concentration	Y	Y	-	-	-	-
Verbal instructions	Need of additional modalities	Y	Y	Y	Y	Y	Y
Verbal instructions	Feel of movement	Y	Y	-	-	-	-
Physical contact and guidance	Benefits of physical contact based methods	Y	Y	Y	Y	Y	Y
Physical contact and guidance	Consent and preferences for physical contact	Y	Y	Y	Y	Y	-
Physical contact and guidance	Impact of the Covid-19	Y	Y	Y	-	-	-
Physical contact and guidance	Inherent physical contact	Y	Y	Y	Y	Y	Y
Tools supporting teaching	3D modals, tactile diagrams, recording sound	Y	Y	Y	Y	Y	Y
Community sharing and practice	Professional bodies and consultations	Y	-	Y	Y	Y	Y
Community sharing and practice	Different experts' perspectives	-	-	-	Y	-	Y
Spatial and social awareness	Awareness of others	Y	Y	Y	Y	Y	Y
Spatial and social awareness	Turning moves	Y	Y	Y	Y	Y	Y
Spatial and social awareness	Needs on contrast	Y	Y	-	Y	Y	-
Spatial and social awareness	Safety concerns	Y	Y	Y	Y	-	Y
Support system	Benefits of support persons	Y	Y	Y	-	-	-
Support system	Copying another	Y	Y	-	-	-	-
Motivations	Social reasons	Y	Y	-	-	-	-
Motivations	Impact of Covid-19	Y	Y	-	-	-	-
Online learning and teaching	Expertise with using new technologies	Y	Y	Y	-	-	-
Online learning and teaching	Online content	Y	Y	-	-	-	-
Online learning and teaching	Lack of feedback	Y	Y	-	-	-	-
Body awareness	Body posture	Y	Y	Y	Y	Y	Y
Body awareness	Kinesthetics and proprioception	Y	Y	Y	Y	-	Y
Body awareness	Body balance	Y	Y	Y	Y	Y	Y
Movement qualities	Force and weight transfer	Y	Y	Y	Y	Y	Y
Movement qualities	Speed and timing	-	-	-	Y	Y	Y

Table 7: Themes emerged from interview study and focus group study analysis. 'I' represents interviews, 'F' represents focus groups, 'T' represents teachers, 'S' represents BLV students and 'Y' indicates in which study the theme emerged.