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Assistive Technologies in Dance Education for Individuals with Disabilities: Applications and Limitations

Lauren Lee

Busan Foreign School, Republic of Korea

ABSTRACT

This research paper assesses the barriers individuals with disabilities face in accessing dance education and investigates the potential for advanced assistive technologies to help them surmount these barriers. It focuses on three specific emerging technologies—motion capture, virtual/augmented reality, and haptic feedback devices—and evaluates their potential to make dance education more inclusive for disabled dancers, as well as their limitations, drawing on a wide range of case studies. It concludes that all three technologies could significantly erode training barriers, both by providing dancers with new tools for learning and self expression and by helping dance educators better understand and meet the needs of disabled dancers. However, it acknowledges that certain technologies may be better suited for dancers with certain types of disabilities, with motion capture more likely to aid dancers with mobility disabilities and haptic feedback devices more likely to aid dancers with sensory disabilities. Furthermore, it recognizes that, despite their considerable potential to erode training barriers, assistive technologies offer less promise when it comes to reducing the logistical and attitudinal barriers faced by disabled dancers. Finally, it warns against the use of assistive technologies to erase perceived imperfections, underscoring that these technologies should be embraced as tools for learning and expression rather than to "help" disabled dancers to conform to ableist standards.

Introduction

Dance is widely recognized to offer significant benefits for individuals with disabilities, promoting both physical and emotional well-being. In terms of physical well-being, dance has been shown to improve flexibility, strength, and coordination, as well as cardiovascular health and pain management ("The Benefits of Dance"). In terms of emotional well-being, research indicates that for disabled individuals, participation in exercise and sport-related activities, such as dance, correlates with higher perceptions of self-efficacy and social competence (Hutzler & Korsensky). Furthermore, it has been observed that dance empowers disabled individuals to express themselves creatively and to challenge ableist stereotypes (Lindsay). It may even be argued that dance constitutes a fundamental human right—the Convention on the Rights of Persons with Disabilities emphasizes the right of individuals with disabilities to participate in cultural life, recreation, leisure, and sport on an equal basis with others, and dance lies at the intersection of those categories ("Convention on the Rights of Persons with Disabilities"). Such observations and arguments have fueled the creation of a plethora of organizations and initiatives around the world seeking to make dance more accessible to disabled individuals.

Yet despite a broad consensus about the importance of dance education for individuals with disabilities and the concerted efforts of activists to make dance more accessible, disabled individuals often find themselves excluded from opportunities to learn dance. Disabled individuals who wish to pursue dance education face several distinct barriers. First, there are training barriers. Most dance syllabi encourage students to aspire to preconceived ideals or standards that were designed for able-bodied dancers and that may be unattainable for those with limited mobility, such as individuals in wheelchairs (Shibata). Moreover, because dance involves both visual and auditory components,

it may be more difficult for individuals without fully functioning eyes and ears to learn traditional dance forms (Ritzel). Even those with neurodivergent disorders, such as autism, may face training barriers, such as heightened sensitivity to sensory stimuli like bright lights and loud noises, which are common components of dance education (Bress). Given their unique needs, dancers with disabilities often require specialized training, but this can be difficult to find. The majority of dance instructors have little experience working with disabled students and thus lack the knowledge to effectively train them (Aujla & Redding). Moreover, while there are a number of existing programs that aim to introduce disabled individuals to dance in a recreational or therapeutic context, there is a dearth of accredited courses and vocational training (Aujla & Redding). This means that disabled dancers have few opportunities to build the technical competence needed to pursue dance at a high level (Aujla & Redding). Second, disabled dancers may face logistical barriers. It has been observed that disabled dancers often require more intensive training, which can pose a prohibitive burden to families with limited time and financial resources to spare (Aujla & Redding). This burden is exacerbated by the fact that disabled dancers may need to travel greater distances to access training and may not be able to use public transportation (Aujla & Redding). Third, disabled dancers may face attitudinal barriers. Pernicious stereotypes such as the notion that dance is impossible or inappropriate for the disabled can discourage people with disabilities from pursuing dance education (Aujla & Redding). Sometimes this discouragement can come from those with good intentions, such as parents who wish to protect their children from disappointment or educators who focus on the therapeutic aspects of dance rather than achievement, but it can nevertheless prevent disabled dancers from reaching their full potential (Aujla & Redding). Finally, it is important to note that these barriers, while distinct, may compound one another. For example, training barriers may prevent disabled people from reaching high levels of achievement in dance, reinforcing attitudinal barriers, which in turn result in fewer efforts to include disabled people in dance education, exacerbating training barriers.

In light of these pernicious barriers, there have been growing calls for reforms that would make dance education more accessible to disabled individuals. Some of these reforms have centered on the use of advanced assistive technologies to mitigate the barriers faced by disabled dancers. For instance, the Korea International Accessible Dance Festival (KIADA), which markets itself as the world's "only comprehensive disabled dance festival," has noted the potential for assistive technologies to transform the field of disabled dance by "expanding artistic boundaries and offering greater creative possibilities for disabled artists" ("KIADA2024 International Academic Symposium"). Dance researcher Merry L. Morris has also expressed optimism about the integration of assistive technologies in disabled dance, asserting that they would ideally function not merely as medical devices but as "creative, embodied instrument[s] of expression" with the power to enact "an embodied relationship between person and environment" (Butler). Nevertheless, the implementation of advanced assistive technologies in dance training for the disabled is a relatively recent development, and there has been little critical research on the subject. To address this gap, this paper identifies three promising technologies—motion capture, virtual/augmented reality, and haptic feedback devices—and evaluates their potential applications, as well as their limitations, when it comes to making dance education more accessible to people with disabilities.

Discussion

Motion Capture

Motion capture technology involves the use of cameras or optical sensors to record an individual's movements and convert them into data (Sun). Specialized software can then use this data to generate digital animations that replicate and analyze the individual's movements (Sun). Though originally applied almost exclusively within the film industry, motion capture is increasingly being used in education and rehabilitation to offer real-time feedback and detailed analysis of movements (Qianwen).

Though it is difficult to find documented uses of motion capture in dance education for the disabled, there have been numerous instances of applications in general dance education. A prime example is WhoLoDancE (Whole-Body Interaction Learning for Dance Education) Project. Harnessing the power of motion capture, this EU-sponsored initiative recorded over 780 dance sequences across four genres—ballet, contemporary, flamenco, and Greek folk—to create a comprehensive library of movements with "built-in methods allowing enrichment through annotation, segmentation and synthesis" (El Raheb & Ioannidis). This library, in turn, facilitated the production of life-sized visualizations and avatars in mixed reality environments, with the ultimate aim of offering dance instructors "a powerful tool to blend and get inspired by an infinite number of dance compositions from different dance traditions" (El Raheb & Ioannidis). Recent research indicates that dance education that utilizes motion capture, such as the WhoLoDancE Project, may be more effective than conventional forms of dance education (Sun). One recent study on the subject found that motion capture empowers dance instructors to "quickly and effectively help students discover the completion of their own movements through detailed demonstrations and real-time effects feedback, thereby making up for irregular movements" (Sun). It has also been credited with facilitating independent learning and inquiry, as student dancers can utilize models generated through motion capture to make informed adjustments without the active involvement of a teacher (Sun). Given these findings, it is likely that motion capture could have valuable applications in dance education for disabled individuals. In particular, because motion capture can provide precise and instant data on an individual's movements, it could help dance instructors better understand how disabled bodies move. This information could empower them to choreograph dance routines or design dance exercises that are better suited to the unique physical constraints of disabled dancers. Conversely, dancers with disabilities could utilize this data for self analysis and training.

Motion capture may also improve dance education accessibility indirectly by facilitating the creation of better dance tools. Dancers with limited physical mobility often rely on wheelchairs, but conventional wheelchairs are not well designed for dance (Lindsay). Motion capture has already been implemented by designers to create more ergonomic controls for wheelchair users (Thomann et al.). Therefore, it is reasonable to surmise that it could also be harnessed to design a wheelchair optimized for dance. Similarly, motion capture could aid designers in the design of better prosthetic limbs, another tool relied upon by many dances with limited physical mobility. In fact, motion capture has already been used to record and analyze the performance of prosthesis-using disabled dance artists, enabling designers to create "aesthetically personalised prosthetics" that offer disabled dancers new avenues for self expression (Whatley et al.). Through such uses, motion capture offers great potential for eroding the training barriers that render conventional dance education inaccessible to some disabled individuals.

Nevertheless, significant limitations remain. One is that while motion capture has obvious potential for dancers with certain types of disabilities, such as mobility limitations, its applications for dancers with other disabilities, such as neurodivergent disorders and visual or auditory impairment, are less clear. Another limitation is cost. The WhoLoDancE Project aimed to improve accessibility by utilizing "commercially available low-end motion capture devices" and "low-cost sensors and wearables" (El Raheb & Ioannidis). However, even a low cost motion capture system costs around $2,500, and high-end systems such as those used by film studies can cost upwards of $250,000 ("The Challenges of Motion Capture"). Granted, prices have fallen recently and may continue to do so as technologies improve (Sun). Still, motion capture may not be a financially feasible solution for individuals or institutions with limited means. Finally, it has been noted that effectively harnessing the power of motion capture will require interdisciplinary collaboration and that the creation of a meaningful digital pedagogical tool for dance education may represent a "complex constraint satisfaction problem" with conflicting objectives (El Raheb & Ioannidis). For example, the desire to create a scalable tool may be at odds with the desire to create a tool that respects the needs of distinct dance traditions (El Raheb & Ioannidis). Consequently, dance educators will need to think carefully and work closely with experts in other fields to determine how to best implement motion capture to achieve their specific goals.

Virtual Reality and Augmented Reality

Virtual reality (VR) and augmented reality (AR) are technologies that offer immersive and interactive environments that can be tailored to the unique needs of each learner. VR creates a simulated environment in which students can engage and interact, while AR overlays digital information onto the real world, enhancing the learning experience by providing real-time feedback and additional visual cues (Al-Ansi).

Like motion capture technology, VR and AR have yet to be implemented extensively within the specific context of dance education for the disabled. One notable exception is the CoDa Dance Company in England, which has piloted a new intervention that supports people with limited movement, cognition and communication to dance and express themselves through VR and AR ("Dancing for Neurology"). Beyond this application, AR and VR have already demonstrated great promise when it comes to making dance accessible and engaging to disabled audiences. For example, YouDanceWeDance, a collaboration between MAP Design Lab and Pilobolus Dance Theater in the United States, utilized a Magic Leap Headset to project digital dancers into real-world spaces, allowing users to view and interact with dance performances from various angles (Skybetter). Although the primary goal of the project was to enhance dance viewership rather than education, and the primary audience was not individuals with disabilities, it is easy to see how such initiatives could be particularly beneficial for that demographic. In fact, the Birmingham Royal Ballet in England has already been credited with making dance more accessible to neurodivergent audiences, who would be unable to attend the theater in person, through the use of AR and VR to create immersive performances that can be experienced through headsets (Murray). By providing an interactive platform that enables individuals with disabilities to experience dance in new ways, AR and VR could enable users to learn and practice dance movements at their own pace, adapting to their specific physical abilities.

VR and AR have also proven effective at empowering disabled individuals to engage in physical activity. Studies have shown that many disabled people fail to meet globally recommended targets for physical activity, increasing their risk of developing cardiovascular disease and other health complications. To address this problem, researchers at Flinders University in Australia have developed a VR-based program to encourage people with certain types of disabilities to engage in physical exercises, with promising initial results (Ang). Similarly, researchers at Saskatchewan Polytechnic in Canada, in collaboration with the Canada National Institute for the Blind, created VR games specifically designed for visually impaired users to help them engage in physical activities, such as rock climbing (Van Fossen). These projects suggest that AR and VR could provide a safe and controlled environment where visually impaired individuals could explore movements, develop spatial awareness, and enhance their physical fitness and coordination. As such, they offer significant potential as tools to help disabled individuals learn dance.

However, AR and VR are not without their limitations. Though they have already been utilized successfully to promote inclusivity, helping individuals with a wide range of disabilities overcome physical limitations in non-dance contexts, they may not be suitable for individuals with certain types of disabilities. For instance, current VR devices rely almost entirely on vision and may therefore be inaccessible to blind dancers (Anderson). Cost may be another issue. Like that of motion capture systems, the cost of VR and AR systems have dropped considerably in recent years, to the extent that some advocates think these technologies could now represent a scalable intervention to improve accessibility (Ang). Nevertheless, even headsets considered affordable cost several hundred dollars, which could place a burden on low-income families (Greenwald). There are also issues related to ergonomics and ease of use. Heavy headsets and clunky controllers can make VR systems physically uncomfortable, posing significant barriers to entry for some users (Van Fossen). Likewise, some warn that current functions of AR systems like hand tracking could be unstable or unusable for disabled users, such as those with prosthetic limbs or limb paralysis (Van Fossen). Therefore, it is likely that the technology will need to improve before it can be adopted on a wider scale.

Haptic Feedback

Haptic feedback devices simulate the experience of touch, targeting the skin, musculoskeletal system, and nervous system to communicate information to the brain about the outside world (Di Raddo). The use of haptic feedback in digital devices is not exactly a new phenomenon: from trackpads on some laptops to rumble packs on many video game controllers, many everyday items utilize it (Di Raddo). However, one particularly recent development is wearable haptic feedback devices. These untethered, ungrounded body worn devices interact with skin directly or through clothing, typically by producing vibrations or other tactical sensations (Shul & Damian).

As with AR and VR, there have been few documented instances of haptic feedback devices used in the specific context of dance education for disabled individuals, but the technology has already proven itself useful in making dance more accessible to disabled audiences. One intriguing example is the Choreo-haptic Project at Carnegie Mellon in the United States. This project relies on surface haptics rather than wearable haptics, employing sensors that capture dancers' movements in real time and send it to a processor that translates the data into haptic feedback (Di Raddo). Audience members can simply rest their hands on haptic pads that emit vibrations and pulses reflective of how the dancers are moving, the tempo and timing of the dance, and a dancers' movement's effect on body posture (Di Raddo). Those involved with the project have underscored its potential to make dance performances more accessible to visually impaired audiences by allowing them to "feel" the dance they "cannot see" (Di Raddo). As a result, it is likely that it could help visually impaired dancers better to understand dance movements.

Wearable haptic feedback devices offer potentially greater potential for making dance education more accessible to disabled individuals. That's because they allow for greater freedom of movement, enabling users to receive haptic feedback without being encumbered by handheld devices, a feature that would likely be advantageous to dancers. Currently, wearable haptic devices are being utilized to help disabled individuals in a wide range of tasks and activities, including dance. One of the most prominent examples is the SubPac, a device that transfers low, bass frequencies into haptic feedback, providing a physical dimension to sound (Finley). Though originally designed to help music producers avoid hearing damage, it has been utilized by deaf dancers to feel the music they can't hear, enabling them to learn choreography more efficiently (Finley). Another wearable haptic feedback device with potential applications in dance is the HapticSnakes developed at the University of California, Los Angeles in the United States. HapticSnakes are snake-like waist-worn robots that can deliver tactile sensations such as taps, airflow, and brushes to various locations throughout the body (Al-Sada). A study found the use of HapticSnakes in VR environments can lead to a more enjoyable and immersive experience (Al-Sada). As such, they may provide a valuable complement to the VR and AR technologies discussed in the previous section and their potential applications in dance education for the disabled.

Nevertheless, significant limitations to the use of haptic feedback devices in dance education for the disabled remain. First, while haptic feedback devices would likely benefit dancers with sensory disabilities, such as hearing or vision impairments, their potential utility to dancers with other types of disabilities, such as neurological or mobility disabilities, is less apparent. Second, although haptic feedback devices are able to convert visual and auditory information into tactile sensations, their ability to do so remains crude and imprecise. For instance, even proponents of the Choreo-haptic Project concede that the haptic feedback provided only allows the communication of "large, grand movements" and that "small movements, which are often the most vital in dance expression, are lost" (Di Raddo). That may change as the technologies underpinning haptic feedback devices improve, but it is unlikely that any haptic technology could fully recreate the tactile experience of dancing, let alone fully convey the auditory or visual experience to those with impaired hearing or vision (Di Raddo).

Conclusion

The three assistive technologies discussed in this paper—motion capture, VR and AR, and haptic feedback devices—have few, if any, documented applications in dance education for individuals with disabilities. However, the examples and case studies discussed in this paper suggest that all three offer significant potential when it comes to reducing the barriers faced by individuals with disabilities who wish to pursue dance education. These technologies would likely be most effective at helping disabled dancers overcome training barriers. One way they may do so is by making it easier for disabled dancers to participate in dance education designed for non-disabled dancers. For instance, motion capture may enable the creation of tools like dance-optimized wheelchairs and prosthetics that give dancers with mobility disabilities greater freedom to express themselves, while haptic feedback devices may help dancers with sensory disabilities experience dance more fully through tactile sensation. Another way they may do so is by facilitating the creation of new training methods. For instance, motion capture could be harnessed to provide customized feedback to dancers with mobility disablities and to help choreographers design dances more suitable to their unique bodies and abilities, while VR and AR can offer safe and convenient new platforms for dancers with a wide range of disabilities to learn and practice dance moves. However, the potential for assistive technologies to reduce attitudinal barriers is less clear. As long as prejudices remain, individuals with disabilities will likely face unequal access to dance education and may be discouraged from pursuing it in the first place. Granted, assistive technologies may indirectly erode attitudinal barriers by making it easier for disabled individuals to pursue dance, ultimately leading to greater representation and acceptance. However, they could also exacerbate biases by creating the false impression that disabled dancers are incapable of dance without them. Assistive technologies also offer less promise when it comes to eroding logistical barriers. Although they may ultimately lower the cost of dance education by reducing reliance on human instructors, for the time being, most of these technologies are not cheap, and may therefore be unaffordable to many dancers with disabilities. In short, despite their notable potential, assistive technologies should by no means be viewed as a panacea to the challenges faced by disabled dancers.

Finally, it is important to note that some disabled dancers may reject assistive technologies altogether, finding them unnecessary or even insulting. Despite its cautious approval for assistive technologies, KIADA aptly notes that "often, technology seeks to erase or fix vulnerabilities and imperfections of the body, whereas in dance, especially inclusive dance, these aspects are sources of uniqueness—pride and beauty that contribute to artistic creation itself" ("KIADA2024 International Academic Symposium"). Certainly, individuals with disabilities are capable of expressing themselves through dance without assistive technologies, and the goal of such technologies should not be to "help" disabled dancers conform to ableist standards. Still, for disabled dancers who wish to embrace them, assistive technologies may represent a valuable tool, one that does not seek to erase or fix imperfections but merely to offer a wider range of possibilities for creative expression. As disabled dancer and inclusive dance advocate Suzanne Cowan eloquently explains, "whether it is with prosthetic legs, crutches or a wheelchair, we create our own unique configurations in performance. When we engage this broader perspective, the term 'disability' is no longer useful or relevant. Instead it can be redefined as developing interdependence and a porousness" (Cowan).

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