**Title:**
AI-assisted teaching as a method for enhancing ballet instruction for people with disabilities and older adults.

**Abstract**
In ballet, students have historically relied on teachers providing them with feedback after executing a combination – a method of teaching that has changed little over the years. Students, especially those with disabilities and older adults, may not receive as much attention or feedback as other students, or may not have the opportunity to practice ballet at all. We argue that this opportunity gap, along with other creative challenges in teaching, may be addressed with artificial intelligence (AI). This paper synthesizes research on the potential for AI to be integrated into ballet teaching, highlighting how it may benefit dancers with different skill levels and access needs, such as people with disabilities and older adults. We discuss how AI may be beneficial in providing personalized feedback, creating choreography, preventing injuries, helping students learn choreography, improving remote ballet classes, and helping teachers generate combinations for class. Importantly, however, AI should not fully replace dance teachers and engineers should ensure that the AI is trained to support a diverse group of dancers.

**Introduction**
Although dance has many benefits for people, the current state of ballet teaching isn't accessible for people with disabilities, the elderly, and many other groups of people. Dance has many physiological and psychological benefits, such improving mobility and providing interactions with a peer group and community. Dance has been shown to improve balance and walking speeds more in the elderly more than just walking as exercise **(Earhart, 2009)**. It may also benefit people with Parkinson's and similar disorders because it provides a means of visualizing movement patterns, which helps them improve in walking backwards and other movements that are difficult for people with Parkinson's. In addition, dance is an important example of aerobic exercise, which improves endurance and strength. Similarly, dance provides an alternative to running or playing sports for physical activity, which may benefit people with disabilities for whom traditional forms of physical activity are not accessible. In addition, the social aspect of dance provides significant benefits to the elderly and to people with disabilities and people who are neurodivergent. Ballet provides a means of communication and interaction with a peer group through physical movement in addition to verbal communication. This may be able to help people with disabilities build relationships with their peers in a way that is more comfortable for them **(Reinders et al., 2019)**.

However, classes may have to be structured in a way that is more accessible to people with disabilities, mobility issues, and the elderly. For many groups, physical limitations and disabilities may limit people's ability to fully participate in a class and with their peers. In the case of children with Autism Spectrum Disorder, they may have difficulty forming relationships with their peers, because of embarrassment or negative interactions. In addition, dance classes and specific movements are not always structured in a way that is accessible or even possible for the elderly or people with disabilities to execute. However, it is possible to adapt ballet classes to be more accessible for neurodivergent people, those with disabilities, and the elderly. Artificial

Intelligence (AI) has the capacity to help create a more supportive and accessible ballet class, by complementing dance teachers' feedback and support.

**Background**

The current state of dance education is strongly based on historic techniques and specific styles that are passed down from teacher to student. There are a number of unique styles of ballet that are specific to regions and particular schools - such as the Vaganova method, which is unique to Russia and the former USSR, and the Balanchine style, which is unique to the American Ballet Theatre and New York City Ballet. These unique styles and methods have been passed down from their original creators - Agrippina Vaganova and George Balanchine - to their students, who then passed it down to the next generation (MasterClass, 2021). Much of ballet education is based on historic trends and methods of teaching that haven't evolved much over the years. Because of the major emphasis on a teacher's own training, there is a significant reliance on whether a particular teacher notices a student's mistakes and offers corrections or not. Because of this history, ballet classes can be inaccessible for people with disabilities and older adults because a teacher may not offer them feedback.

Over the course of the last year, a number of significant advances in artificial intelligence have taken place, particularly with generative AI. Most commonly known and used of these is ChatGPT, which has been the target of much discussion of its uses in different fields, particularly education. For example, teachers may use this technology to generate lesson plans, questions, and more, while students may use it to summarize long articles, generate text, and answer complex questions. Specifically, as much of ballet instruction is passed down through, Generative AI may be able to help teachers and students summarize texts about dance and reduce the amount of time teachers spend taking notes on these texts. They may also help teachers generate feedback for students and help students find exercises to strengthen certain muscles. Similarly, they can also help teachers create personalized exercise regimens that reduce injury risk for students, particularly those with specific access needs. They also can be trained to write out choreography and specific tips for certain variations or parts of variations, so students can more easily get help with choreography. In addition, generative AI may be trained to create choreography or assist teachers in creating choreography, so that teachers can spend more time on individual students' technique.

Another recent development is the continued advancement of video analysis and computer vision technology. This is when AI "sees" and identifies objects, people, and things happening in a video. This is a technology that is still being worked on and its applications to different areas are still being debated **(Metz, 2023)**. In addition, video analysis with AI can be used to create choreography by analyzing a dancer's movements and predicting the next step (*Living Archive: Creating Choreography With Artificial Intelligence - Google Arts & Culture*, n.d.). They can also be used to better understand a dancer's movements and which muscles they are using. This can help teachers better understand injuries and injury risks in particular dancers. Another emerging technology is Mixed Reality, which is a blend of both physical and digital **(Qianw, 2023)**. This, along with other forms of Augmented and Virtual Reality, have been brought to the forefront of much discussion with Apple's announcement of its new mixed-reality headset, "Vision Pro" **(Gurman, 2023).** These technologies may be used to give students the

opportunity to “take class” virtually with prestigious schools and well-known teachers that they don’t have access to . In addition this may help students learn choreography when they aren’t able to be in the studio and understand where they are supposed to be in relation to other dancers **(Joe, 2023)**. These may help people with disabilities and older adults prevent injuries, correct movement patterns, and be more immersed in their ballet class.

In conclusion, AI-assisted dance teaching has the capacity to make dance instruction **more personalized** for students, **less time-consuming** for teachers, and **more accessible** for older adults and people with disabilities.

**Digital Dance Teaching**

Digital Dance Teaching has mostly developed into 2 forms, especially as a result of the COVID-19 Pandemic. The first version is a fully remote model, both teacher and student on Zoom. While there are some benefits to this method of dance teaching, like the fact that students can join from anywhere and that they are less expensive, there are still some significant downsides. In particular is the teacher’s inability to correct a student’s movement or even see if a student is making a mistake **(Moran, 2020)**. Another form of remote dance teaching is a hybrid model, with some remote classes and some in-person. This method allows students to experience both in-person classes, where they can get corrections and feedback from teachers, and online classes, where they are under less pressure and can benefit from online classes **(Kahn, 2022)**. Digital dance teaching does have benefits for people with disabilities and older adults because they are a lower-pressure environment that can help these groups find confidence and a more supportive ballet class.

**Neurodivergent Dancers and Dancers with Disabilities**

Dance presents many benefits to the elderly, like improved balance and social interaction **(Earhart, 2009).** However, much of a typical ballet class is not safe for the elderly, especially jumping and pointe work. In addition to that, they may not be able to participate in a long class, needing to take breaks **(Earhart, 2009).** AI may have significant benefits for these students and their teachers. It could help teachers notice potential injury risk, particularly in the knees and hips **(Reid, 1988).** It may also help both students and teachers adapt combinations for physical limitations that they may have. In addition, generative AI may help teachers create choreography that is suitable and safe for the elderly. It may also help teachers find exercises that may improve a student’s mobility and strength. Lastly, AR/VR technologies may help students participate in dance class in a place that is closer for them and feel immersed in dance class and shows.

Dance also presents significant benefits for neurodivergent people and people with disabilities. In particular, dance is a form of exercise that is different from competitive team sports and provides a way of forming relationships with others that may be easier for neurodivergent people, particularly children. Additionally, it is a way of communicating physically, which can help people that have difficulty interacting with others **(Reinders et al., 2019).** AI may be able to both students and teachers adapt dance classes to be accessible to people with disabilities. AI could help teachers adapt classes to be more suitable to people’s specific needs and limitations. It may also help a teacher notice a student's error and help them improve in a

way that works for them. It also gives students the opportunity to find feedback if they don't feel comfortable talking to a group or their teacher.

**Future of Online Dance Teaching**

One possible scenario for the introduction of AI to dance teaching is in person classes, with AI assistance. One particular direction for this may be the use of motion tracking technology, as described by Patil et al. (2022). . This paper describes a motion tracker that could be used to provide feedback on posture when exercising. This motion tracker would plot the movement of certain joints and analyze this in order to mimic professional feedback **(Patil et al., 2022)**. A similar method could be applied to ballet teaching, in which the movements of certain joints or bones could be plotted, analyzed, and compared in order to provide corrections like a dance teacher. This could help identify which muscles and joints a student is using incorrectly and adapt exercises and class to help prevent injuries (*How an AI-based "Super Teaching Assistant" Could Revolutionize Learning | Stanford University School of Engineering*, 2020)**.** Another way of plotting a dancer's movements could be by utilizing "stick figures" as described in (*Living Archive: Creating Choreography With Artificial Intelligence - Google Arts & Culture*, n.d.)**.** This could be used to provide feedback on choreography and larger mistakes that a student made, as opposed to more specific muscle and joint-related feedback. In addition, a video of a dancer could be analyzed and cataloged using Laban Movement Analysis (LMA). LMA is a system of describing the way a person moves their body and is used by dancers, choreographers, and actors **(Woltmann, 2022).**

Another AI technology that might impact dance teaching is generative AI. Generative AI describes a type of technology that creates content, such as text, image, or audio. Generative AI models are built by training them on large amounts of training data, like text or image (*What Is Generative AI?*, 2023)**.** Similar to the way that these models are built and trained, a model could be built to generate choreography. Like **Google Arts and Culture's Living Archive**, these models could be trained on choreography that has been cataloged using LMA **(Guo et al., 2022a).** These models may be able to help teachers generate combinations for class and help create choreography for class and for shows, by giving teachers inspiration and possible solutions to issues that arise during choreography. In addition, this model may be able to help teachers continue creating choreography, even when they are unsure or lack ideas, by generating a possible movement based on the past choreography **(Joshi & Chakrabarty, 2021).**

Another possibility is a completely online method of teaching. Currently, there are many videos and online classes to learn ballet, but it is difficult to receive feedback during these classes. As it is difficult for a teacher to see which muscles or joints a person is using. By using motion tracking technologies, it may be possible to improve this **(Patil et al., 2022).** Additionally, by analyzing the video of a person dancing, the AI may be able to find mistakes. This would make it possible for a student to be able to analyze their own dancing and improve without needing to be with a teacher or someone else in the room.

Another possible direction for the future of dance teaching is the use of extended reality (XR) (*Home*, n.d.)**.** XR is a term that encompasses AR (augmented reality), VR (virtual reality) and MR (mixed reality) **(Goode, 2018)**. These technologies have the possibility to bring dance to

life, by offering students the ability to immerse themselves in a dance class (*View of My Choreographer: An Augmented Reality Dance Training System*, n.d.). By using a headset, students can feel like they are actually in a studio and are able to take class with prestigious teachers and when they aren't able to be at the studio. In addition, this poses significant benefits for choreography. When students aren't able to be at rehearsals, they can use these technologies to learn the choreography and understand their place in relation to others. This will help choreographers teach choreography quicker and for students to review the choreography.

## Discussion

### Choreography as a Protected Art

There are a number of concerns however, with the use of AI in dance teaching. One such concern rises from the use of choreography and movements to train the AI and the potential for exploiting artists' work. Many artists believe that generative AI infringes on their work and uses it without their permission (Chayka, 2023). However, this concern applies more to contemporary and modern styles of dance, which are more likely to be protected. This concern applies differently to ballet because while specific ballets may be copyrighted, individual stylistic features and movements are not **(Vargas, 2021)**. In addition, pieces that were choreographed before 1978 and were not copyrighted - which includes most classical ballets - are not protected **(Kaufman, 2000).**

There also is a concern that the spirit of creativity and emotion in dance will be eliminated. Especially with generative AI, many artists are concerned that their jobs as creators will be eliminated by AI. Many are concerned that it will limit the way that art conveys emotions and experiences. However AI is better as a tool to help artists create, as opposed to generating choreography on its own (*The Quest for AI Creativity*, n.d.). AI can help fill the gaps when choreographers are feeling stuck. Meanwhile, AR can help students feel immersed in choreography when they can't be at the studio. It can help teachers find feedback for mistakes students are making. AI is better used as a tool to help people create art, than to create art by itself.

### Diversity & Access

Another concern is about a lack of representative data and the AI not being able to support diverse dancers. This rises from the lack of diversity within the ballet world. Much of this lack of diversity rises from the high cost of training, a lack of role models, and a certain image that many have of what ballet looks like: [thin, tall, and white] (Pickard, 2013). If AI is training on existing footage of professional dance companies who uphold these body ideals, there is a risk that it may not recognize or be able to support diverse groups of dancers **(Carman, 2021)**. For example, AI trained on professional companies wouldn't be able to take into account the specific physical limitations that older adults and people with disabilities have and would expect them to be able to perform certain movements that would not be safe or possible. Thus, the stereotypes perpetuated by the data should be taken into consideration, and careful forethought must be given to using a diverse set of data in order to support older adults, people with disabilities, and other diverse groups.

Another limitation is the high cost of integrating these technologies. The cost of making and maintaining generative AI is very high, because it requires a large amount of computing power and special hardware **(Vanian & Leswing, 2023).** Also, AR and VR hardware has a high cost, particularly headsets. In addition, the research and technological improvement necessary for these to be practical to apply to dance teaching may require a lot of funding. Especially as these technologies are still being developed, the high cost may hinder its application to dance instruction. In addition, given the high cost, only wealthy organizations would be able to access these types of technologies, but people with disabilities and older adults may not have the funds to access this technology. However, as these improve and are further developed, costs may lower.

**Human-AI Complementarity**

Human-AI Complementarity is the use of human-AI collaboration, as opposed to AI being used to replace human involvement. Both could collaborate to solve problems and produce solutions. This may be applied to dance teaching in a number of ways, as earlier discussed in this paper. One possible application of this is generative AI being used by either teachers or students to improve their teaching or technique. Another possible application of this is the use of motion tracking to analyze a dancer's movement to provide feedback. Both of these examples use AI as another tool to improve dance teaching for both students and teachers. However, this may require more advancement in AI technologies, so that they can better be integrated with teachers. In addition, more research is needed for these technologies to be supportive of diverse groups of dancers, with unique physical limitations.

**Technical Feasibility**

Another limitation is that many of these technologies, particularly virtual and augmented reality, have yet to mature in a way that would be practical for application to dance teaching. In particular, wearing a heavy headset isn't practical for a ballet class. In addition, wearing a headset might make it difficult to practice certain techniques and posture, because of the added weight **(Kafka, 2023).** Another concern may be that the whole body, particularly the legs, haven't been represented realistically **(Metz, 2022).** This may limit its ability to improve dance teaching, because much of the training focuses on the movement of the arms and legs. A final concern is that many people do experience discomfort and dizziness after using VR headsets for long periods of time. This may also make teaching dance difficult for students and teachers.

**Conclusion**

AI presents many benefits to ballet teaching, including more personalized feedback, assistance for teachers, and a more immersive experience. This paper analyzes the benefits of different emerging AI technologies, like generative AI and mixed reality. This paper also highlights the benefits that these technologies may have for older adults and people with disabilities who are looking to participate in ballet, such as better adapting class to specific limitations and preventing injuries. However, some advancement in these technologies is necessary for these developments to take place and more research understanding how they can be integrated into ballet teaching is required.

Sources

Formatting Instructions