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An Exploration Into Digital Technology and Applications for the Advancement of Dance Education

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AN EXPLORATION INTO DIGITAL TECHNOLOGY AND APPLICATIONS FOR THE ADVANCEMENT OF DANCE EDUCATION

THESIS

Submitted in partial satisfaction of the requirements
for the degree of

MASTER OF FINE ARTS

In Dance

by

Carl D. Sanders, Jr.

Thesis Committee:
Professor Lisa Naugle, PhD, Chair
Professor Mary Corey
Professor Alan Terricciano

2021

DEDICATION

To

My supportive wife Mariana Sanders

My loyal alebrijes Koda-Bella-Zen

My loving mother Faye and father Carl Sanders

My encouraging sister Shawana Sanders-Swain

My spiritual brothers Dr. Ras Mikey C., Marc Spaulding, and Marshall King

Those who have contributed to my life experiences, shaping my artistry.

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ABSTRACT OF THE THESIS

An Exploration Into Digital Technology for the Advancement of Dance Education

By

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Master of Fine Arts in Dance

University of California, Irvine, 2021

Professor Lisa Naugle, PhD, Chair

In March 2020, the Coronavirus Pandemic began to spread rapidly worldwide, shutting down establishments, restricting physical interactions, and forcing all communication between educators and students to be mediated by technology. Evidence pre Covid-19 shows a slow incorporation of digital literacy among university dance students. But under new restrictions, for the field of Dance, online learning and virtual streaming of performances became dominant. Educators and students have become part of what appears to be a new era in dance teaching, creation, and public presentation. As the pandemic continued from weeks to months and more than a year, the importance of dance with technology has become an imperative necessity for the increased learning and communication. A new collective consciousness about digital literacy has emerged, and people in the field of dance are using new methods and embracing previously unimagined digital technology as part of the learning environment.

This thesis explores the use of portable digital devices as educational and creative tools for the expansion of 21st century dance academia and training. Investigations into previous and current methods of engaging dancers in digital literacy through the learning, development, creation, implementation, and dissemination of tech inspired movement are researched to

identify newer methods of teaching dance with technology. This research furthers the ideas of integration by experimenting with the use of an autonomous robot as an (A) video monitoring tool to enhance mobility as an instructor or student in a virtual dance class setting, (B) example of robot use as an educational and creative tool for in-studio student exploration and interdisciplinary learning. As well as, (C) the programming and incorporation of AI functionalities for student choreographic projects. Findings from these experiences are then composed into a series of learning experiments including physical training exercises that may be useful for an *Introduction to Robotics and Dancers Course*.

INTRODUCTION

As digital technology expands the ways in which people communicate and interact, it has become increasingly important for teachers and students to have access to a variety of technological tools to support instruction, creative exploration, and learning. Dancemakers have naturally gravitated toward technological innovations that enable a deeper understanding of the human body in motion. Through the use of portable computers, wearable technologies, and software apps dancers may create, design, participate and move in new modes of performance. Opportunities between dancers and choreographers inherently explore new methods out of a desire to expand their imagination, talent, and intellect. However, the adoption of digital components and methods for integration into dance training has been slow in its incorporation into the formal practice of dance. The onset of the COVID-19 Pandemic has taught us that now is the time in dance education to support students by equipping them with new technical options alongside their physical training. Such practice increases digital literacy and technological capabilities that will enhance their engagement with 21st century skills in the professional and business aspects of dance and potentially advance the perception of dance as an important field of study in universities of the future. In what ways does dance training with digital devices support a student's development toward digital literacy and choreography? This question drives the research presented on the following pages.

Background

In Fall 2019, I was in a lecture course taking notes on an iPad while a professor-selected film was projected onto a screen in the classroom. The professor paused in the session and questioned why I was using an iPad, claiming that taking notes with the lights off was impractical and my note taking was inconsiderate to students in the room. I looked around at others and noticed that I was the only person using an electronic system and asked myself, *should I put* *away the "smart device" and use a pen and paper? Or, should I attempt to explain the importance of incorporating the iPad into my learning process?* I quickly thought about my personal history with dance and technology; building custom-made tap shoes, performance stages, websites, apps, social networking platforms, graphic designs, videography, editing, music production, and riding an electric skateboard as a daily activity. My life experiences, choreography for stage, business engagements, social connectivities and academic learning had all become intertwined with the how, why and when to use technology. Perplexed by the instructor's comment, I felt restricted in learning and discouraged to acknowledge the skills I valued and worked to acquire. I decided to advocate for taking notes on my iPad by explaining to the instructor that the device brightness could be adjusted and that we are both using technology (the projector for teaching and the tablet for learning). Suddenly there was resounding confirmation and agreement from the other students in the class and the addition of a few more computers from others.

That experience stayed with me for quite some time and persuaded me to shift from doing research on choreography to learning with technology. I began to question how an instructor's encouragement or discouragement affects students' motivation in learning with technology. Learning and experimentation together can be a kind of flow at the heart of dance, and making use of technology in the classroom is part of that experience. Flow as identified by Mihaly Csikszentmihalyi in *Creativity: Flow and the Psychology of Discovery and Invention,* (1996) is where actions and awareness merge, self-consciousness disappears, time becomes distorted, and the activity becomes autotelic, resulting in a state of immersive focus and concentration without worry of failure. "Distraction interrupts flow and it may take hours to recover the peace of mind one needs to get on with the work" (Csikszentmihalyi 1997, 8). The use of technology also supports valuable personal connections which often links to other experiences and life-long learning. If an iPad and other technologies are not included in the current method of learning then how will dance students become more digitally literate? How might new technologies be integrated in dance practice to advance dance performance and scholarship? What types of technology might have the biggest impact on dance students and educators? As a dance instructor, student, choreographer, and technologist, I pride myself on leading pathways of discovery and knowledge through the incorporation of technology. I believe that movement, its creation, techniques, and functionalities are best learned by providing multiple strategies of engaging material. It is for these reasons, that this thesis focuses on digital devices as a necessary component of a dance curriculum.

Currently, a multidisciplinary approach for student choreographers within dance programs includes the use of instructional videos, social media for arts management, cameras and software to film, edit, and distribute screendances, and new developments in synchronous and asynchronous communication. Recent developments in wearable sensor technology that can be applied directly to the body or by secondary smart system products such as intelligent bands, glasses, shirts, watches, and shoes, have body performance and body monitoring applications that may enhance dance artistry, especially within interactive projects, movement analytics, wellness, and injury prevention. The incorporation of audio and video software and techniques allows dancers to design, edit, apply graphics, visuals, and sound to their creative work. All of these technical skills are in addition to training the body and understanding the aesthetic value and meaning. Despite how commonplace, these tools have not yet become fully implemented as mandatory studies and practices of dance.

In the pages that follow, this thesis will discuss the implementation of digital literacy as it pertains to the education of 21st century dancers. The methodology of this research consists of publications involving the historical background of dance and digital literacy, through the advent of digital media applications; as well as a brief examination of some university programs that are offering courses to comprise a full spectrum of knowledge for movers and designers of the tech infused dance world.

Additionally, this research takes the reader through a short overview of some of the most prominent choreographers whose collaborations, movement, and innovations involved the use of digital technology; from computerized movement research and robot interface choreography to wireless sensor technology and electric muscle stimulation systems. This research investigates multiple methods of engaging movement through the creation of an interpersonal relationship with technological devices, what new knowledge can be obtained from that experience, and implemented into the formal practices of dance. I provide a taxonomy of portable devices that may suit the needs for dance education and creation. My method includes the use of four consumer digital products, the *DJI RoboMaster S1* educational electric robot vehicle with (AI) Artificial Intelligence Technology, the *DJI Osmos Action* stabilization camera with a Voice Control Recognition Software. In addition, an *Apple iPhone Pro* and *iPad Pro* will assist as programming devices and video monitors. The objective of this investigation is to design a set of introductory experiences for dancers that allows them to integrate portable digital systems in their training.

Chapter 1

Review of Literature

Digital Literacy in Dance

Digital Literacy, as defined by The American Library Association (ALA), “is the ability to use digital information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills" (US Digital Literacy, 2019). For dance practitioners and educators, this includes the ability to create basic texts, videos, images, and audio files in relation to dance activities. However, there are also foundational skills necessary to be able to technically produce extended functions. These foundational skills include the navigation of software applications, digital editing capabilities, graphic design techniques, and the knowledge of file sharing parameters. Such skill sets assist artists in the creation of content and managing social networking analytics online; this involves the use of digitally graphed diagrams and tables to analyze, control, and monitor business processes, workflows and self branding, which is an online form of marketing that most artists use to create a uniform public image that demonstrates their values and overall digital reputation. For dancers to be able to transition into these foundational skills, educators and students might recognize that this may have to be achieved through multiple courses and projects. But, as stated in the *Performance and Technology* journal article “Materials vs Content in Digitally Mediated Performance”, by pioneering media performance artist, composer, and digital programmer Mark Conigilo, “using new technology to further expression has always been the realm of the artists" (2011, 80).

In Steve Dixon’s *Digital Performance: A History of New Media in Theater, Dance, Performance Art, and Installation* he finds, “that new technology’s influence on the arts, aesthetics, creativity, and culture has been no less revolutionary, significantly affecting processes and production to creative writing and the visual and performance art" (2007, 80). In turn, dance has, in many cases, been a pivotal skill that has added to the diverse and creative lineage of experimentation in the performing arts and technological advancements. Over the decades dance and technology has unlocked new movement vocabulary, expressions and perspectives on the relationship between a dancing body and objects, and inspired new applications of its data. However, the technical skills and knowledge from these advancements do not have a long or deep history in dance education because they have not found their way into traditional studio practices. In most college and university dance education programs, the extent to which technologies are utilized in the dance studio is often limited to the use of computers for writing or research, a piano or audio equipment to play music, lighting to silhouette or light the body, the mirror and ballet barre to support alignment, a video camera or smartphone to document movement, and projector-screen arrangements or televisions for video playback. Over the decades, technology has become faster, more portable, more affordable, and smarter and yet the traditional dance classroom and studio has not (for the most part) kept up with 21st Century needs and has been slow to embrace curriculums that support digital literacy.

In their article, *Digital Dance Literacy:* "An integrated dance technology curriculum pilot project", Doug Rinsner and Jon Anderson, claim that although the technological methods in which dance artists create, develop, document and present their work has grown significantly over the past decades, technology education in undergraduate dance curricula in the US often remains peripheral. Some dance programs in higher education, especially those with graduate programs, now include a general course in dance technology that often functions as an overview of documentation methods and basic dance production. Higher education institutions sought to fill this void of technological competency among dancers with introductions to digital technology by the turn of the 21st century.

Kathleen Smith stated in her 2018 *Dance International* article "The Evolving Story of Dance on Film: An overview of new forms then and now":

> By the mid 2000's, the digital revolution was impacting everything to do with film and video making. New technologies such as virtual reality (VR), augmented reality (AR), mobile internet and social media appeared seemingly overnight. The terminology and discourse surrounding the body and media arts also became more investigative, with thinking about performance, dance, interactivity and the screen evolving and expanding across and between disciplines.

Leading Dance Departments at institutions such as Arizona State University, New York University Tisch School of the Arts, Ohio State University, and the University of California, Irvine, to name a few, have a handful of dance technology courses for both undergraduate and graduate students. The focus of these courses is centered around providing a supportive environment for student experimentation and discoveries in new ways of developing digitally inspired choreographic works. Some of these university curriculums even include approaches for both live stage and virtual reality interactive performance. Recently UC, Irvine implemented a live streaming course in a direct response to the new and emerging needs of dancers during the pandemic. In addition, courses in the art of screendance as it relates to filming the moving body, incorporates the learning and development of interdisciplinary skills such as history of film, directing, camera editing, dance, and choreography. Particularly since the Covid-19 pandemic creators of screendance have developed new collaboration techniques through the use of *Zoom* and social media. As students create and engage with others online their presence is experienced by others through authentic branding, website, and media content portfolio. An emphasis on engagement with social media and the promotion of an online presence seems significant to current and future courses in dance education.

Artists often benefit from those who are successful entrepreneurs, and have experience with social media, designing, or collaborating on technology-based projects. Conner Lim and Evan Zhou are independent artists and co-founders of *Steezy*, a digital platform that helps in shaping how commercial dance is learned online. *Steezy's* user-friendly interface, video tutorials, tips, and reviews open a new approach to teaching that allows for independent learning. In the digital studio [https://www.steezy.co/], dancers learn movement at their own pace by using functions such as video mirroring, movement looping, tempo control, side- by-side student/instructor camera view, jump to section instruction, goal setting, tailored sessions, and the ability to learn in virtual groups. "Platforms", the hardware or digital operating system engineered to create virtual environments to support content, may be considered a virtual dance studio. The virtual studio platform is a structure that addresses some of the needs of dance learners both inside and outside of the traditional dance curriculum. This opens new doors for the kind of guest artists who can be brought into dance programs and add to new work being explored in the professional world of dance. As new innovative applications and platforms emerge from developers and digital literacy spreads among the performing arts; fulfilling the need for movement in digital spaces is expanding rapidly, sparking new activities in the teaching, learning, creation and production of dance.

In *Dance and Media Technologies* "A Journal of Performance and Art" PAJ 70: 2002*,* Johannes Birringer, an independent media choreographer and artistic director of AlienNation Co., a multimedia ensemble states:

> As leaps in technological advancements and digital literacy grew [referring to the 1990's] among creatives, the need for interdisciplinary collaborations in the pursuit of embracing the future of the digital experience increased. Many interests in related fields (film, digital arts, science and technology, design, engineering, medicine, telecommunications, etc.) furthered our understanding of complementary thinking processes that drive new interdisciplinary research and conceptual models influxed by the computer's information processing capabilities and the internet's global reach.

One of the most powerful digital devices in common use with dancers is the smartphone. This mobile device performs many of the functions of a computer, television, camera, and of course a phone, typically having a touchscreen interface, internet access, and an operating system capable of running downloaded applications. Advancements of the smartphone have inspired the evolution of pocket and home computing, providing dance artists with a portable means of researching almost anytime and anywhere, experimenting with movement through software programs, and developing their career through social media. Sydney Skybetter, dance technologist, choreographer, and educator at Brown University leads the Conference of Research on Choreographic Interfaces (CRCI) which is a multidisciplinary gathering of innovators in the pursuit of evolving a better understanding of "the future of humans in motion" (Wozy, 2017). Skybetter states that "it's my job to consider how emerging technologies affect dancerly aesthetics and culture, as well as work extensively with all manner of bonkers tech to understand its movement" (Wozny, 2017). Skybetter is promoting a practice of dance that merges with the evolving development of surveillance technologies that incorporate interactive motion gestural control capabilities.

In *Dance Magazine's* 2020 article "Meet the Choreographic Interface Designer Who Brings Her Dance Knowledge to Google", Skybetter interviews dance artist and interaction Designer Lauren Bebal on her collaboration with Google on "thinking through how people move their bodies, and design the choreography that we use to navigate our phones, computers, and other still-emerging technologies".

Lauren Bebal states:

> Interacting with digital information in 3D space contains similar elements to choreography. Just like a choreographer, an interaction designer needs to understand the movement of the body, in space, over time. Advances in gesture recognition technology require a new choreography of in-air hand gestures to interact with objects such as 'pinch' to select options, 'swipe' to skip screens, and a 'bloom' to open menus. Designers in this space are actively defining a new lexicon of movements to create intuitive methods of interaction (Skybetter, 2020).

Interaction design is a relatively new field for choreographers. It requires training in 3D design and programming skills, areas of study not commonly known nor promoted as strongly as traditional professional career paths such as performing and teaching dance; thereby restricting the options of students' movement knowledge. New professions that benefit from dance training are an outgrowth from our ever developing digital world.

Early investigations made by pioneering artists such as Merce Cunningham, implemented methods of using computer programming to create live performances. Cunningham's 1999 work entitled *BIPED*, was an exploration into the possibilities of animation technology of motion capture for both the development of choreography and the presentation of on stage digital visual effects. The *LifeForms* program Cunningham used, was conceived by dancer and software designer Thecla Shiporst in 1989 at Simon Frasier University. This software has continued to help in transforming the use of choreography and interface design for dance, by generating complex three dimensional movement ideas that can be viewed and manipulated from different perspectives and multiple times over.

In Kirsten Bodensteiner's 2012 *Kennedy Center* article "Merce Cunningham + BIPED: Meet the master artist through one of his most important works", she states:

> In 1999, Cunningham used the *LifeForms* program to experiment with choreographic ideas outside the studio. Once he had created a movement phrase with computer figures, he tried it out on his company to see how it worked. Often the sequences of movement were impossible for his dancers to execute, but they would lead to movement choices that he hadn't expected or done before. That was what captivated Cunningham—pushing himself and his dancers outside of what was comfortable or habitual.

Choreographers have often sought to increase the artistic perspectives of themselves, their performers, and audiences through the use of technology. Dance pioneer Bill T. Jones recognized the potential of various kinds of technology from video to motion capture to web browser technology experimentation in the creation of choreography, while providing a digital education for the expansion of his company dancers' minds as well as their bodies. In a collaboration with the *Google Creative Lab* on a project entitled *Body, Movement, Language: A.I Sketches with Bill T. Jones*; they explored the creative possibilities of speech recognition through *PoseNet*, a machine-learning model that estimates human poses in real time through a web browser. A collection of four experiments were built using the *PoseNet* machine learning model running on *Tensorflow.js* software. Jones and the team took full advantage of the creative possibilities of pose estimation technology in designing unique interactions based on voice and movement. Since *PoseNet* can be accessed by anyone using a web-browser and a simple camera, the experiments invite users everywhere to explore the creative possibilities of their own bodies. Working with animation and digital motion is a prominent asset to dance, providing dancers with an ability to transform their movement vocabulary into alternative mediums of expression such as text, sound, images, and computer characterization.

In a 2019 interview with Mutaurwa Mapondera, Bill T. Jones states that:

> I say this with great respect: creating movement through an internet browser interface was almost antithetical to everything I thought dance was. The webcam's field of vision determines a lot about how we move. Dance for us is oftentimes in an empty room that implies infinite space. But working with a webcam, there is a very prescribed space. Limitations are not bad in art making, but there was a new challenge. It was a shift in creating something for the screen and not the stage.

Undoubtedly, the implementation of technology into creative practice is a complex process for some, and for others the merging of movement and digital technology is a more natural approach. Either way, spaces for tech-infused dance training are becoming more accessible everyday, and it is through the continual nurturing of digital literacy that new discoveries emerge. Aspasia Dania, author of *Procedia - Social and Behavioral Sciences* article, “The use of technology in movement and dance education: Recent practices and future perspectives", discusses the influence of technology on dance education through the taking of dance as both a motor skill or a creative practice. This includes the use of digital images, sounds, texts, and graphics to create an interactive multimedia learning environment for dance.

Their goal was to identify new opportunities for personalized instruction, cooperation, feedback, and creative engagement between instructors, dance students, and the technology.

Dania states that “the predominant research finding is that although contemporary technological media are substantially advanced and innovative, they have not been incorporated in the classroom everyday learning practice yet” (2011, pp. 3355-3361). The research determined that factors such as educators having difficulties familiarizing themselves with new technology and how to appropriately incorporate it into their curriculums, the securing of equipment funding, and teacher anxieties surrounding the distraction of technology in dance technique classes all played a large part in the inability of integrating technology into formal dance classes.

Dania states further that:

> A prerequisite for the achievement of this goal is the researchers’ interest to be focused on: a) the cognitive aspects of a technologically supported instruction and b) the design of multimedia products according to the principles of the modern theories of multimedia learning.

In the *Instructional Message Design* article “Multimedia Learning Theory and Instructional Message Design”, Miguel Ramlatchan of Old Dominion University explains that:

> Multimedia learning theory is the use of multiple simultaneous techniques in instructional message design, such as combining narration and visuals in a presentation. It is the process of minimizing irrelevant information, managing essential material, and maximizing working resources for student productivity (2019, 3).

An educator who used such cognitive and technological methods to impact the understanding of the body, electronics and multimedia learning theory was the late dancer and University of Southern California professor Alfred Desio, who first developed a system that allows tap dancers to play electronic instruments using the sound of the taps as a source, introduced in 1982. Made famous by Gregory Hines in the 1989 movie *Tap*, where connected synthesizers allowed Hines to create different audio effects with his shoes. Desio’s creation of *Tap-Tronics* demonstrated new possibilities in digital sound production from foot movement.

Professor Desio openly shared his technology with students of tap, in the hopes of expanding the digital mindset of future dancers and musicians, so that the development of tap technology would continue forward. Since the inception of electronic tap dance footwear, ongoing research in improving its functionality have included the use of Bluetooth technology, MIDI systems, force sensors, amplifiers, microphones, coding software, and in the case of master tap dancer and *Tap-Tronic* student of Desio, Andrew Nemr, the use of Fishman Transducers which triggered sequenced music and live 3D animation in real time for his 2001 thesis performance piece entitled *Looking Within*. Currently, other tap dancers such as MC Shoehorn's *Tappercussion Mark VII E-Tap Controller System* and Nicholas Van Young's *Tap Dance Compositional Instrument* have both taken sound manipulation of foot percussion to new heights by implementing synthesisers directly into the floor. Young's tap technology has been presented in live demonstrations and performances, including a collaboration with Dorrance Dance Company in the 2019 premier of the piece *ETM: Double Down.* This work showcased the connection of how an audio database triggered by movement has an ability to be digitally manipulated from the ground to transcend the traditional outlook of tap. This offers a wide spectrum of possibilities that prove to be beneficial to immersing students in dance musicianship through a cohesive practice of modern technologies in university settings.

The increased use of wireless technology has transformed society over the past five years. Like tap, the area of ballet is increasing its digital experience. Designer Lesia Trubat's ballet pointe shoes electronically trace the movements of dancers and have the potential to significantly enhance the dance training and creative work of ballerinas / ballerinos. [https://www.designboom.com/design/lesia-trubat-e-traces-ballet-shoes-phone-app-10-24-2014/]

Lesia Trubats states:

> *E'traces* ballet pointe shoes are fitted with a "lilypad arduino microcontroller board that records the pressure and actions of the feet, sending signals to an electronic device which connects to a mobile app for customization. Dancers can view all the moves they

> have made in video format, extract images, and print them. This grants them the ability to interpret their choreography and correct it, compare it with others, and can be extrapolated to other disciplines and provides a variety of applications.

Similar to a smart watch one wears around the wrist, the ballet pointe shoe collects data and re-administers that information in a user-friendly interface that enables interdisciplinary education, production and creativity. Such devices like *E'Traces* and other technologies mentioned in this review of literature present a pathway for dance educators, choreographers and student artists to explore and utilize technology in dance training. This also promotes an appreciation and broader understanding of the human body and dance technique in motion, which has the potential to enhance artistic intellect, digital literacy for dancers, and create an educational space within the arts academic studies of dance and technology. Educators must encourage students to take a more active, personal, and technological approach to dance that fits within the scope of their practice. In turn, offering courses to dancers with specific opportunities in digital experimentations will help spread the importance of the incorporation of creative and innovative technologies for the benefit of dance academia and performance.

Chapter 2

Methods

Dance Education and Autonomous Exploration

Inspired by the artists and technologies researched in my review of literature, I began my own journey into discovering ways of expanding the creative movement and digital knowledge of dancers through technology. The objective was to find a digital device that (A) would be affordable enough to suit the budget of a student, educator, or university, (B) incorporate as many of the technologies as possible from the review of literature, and (C) provide convenient portability and connectivity to a smartphone, tablet, or iPad. This was not an easy task, but through further investigative efforts I found a robot that fit every qualification.

I experimented with the *DJI RoboMaster S1*, an educational electric robot vehicle that I built from the ground up. The *S1* supports *Scratch* and *Python* programming software (a coding language that dancers can learn alongside their movement language), which enables Artificial Intelligence (AI) technology such as gesture recognition, autonomous robot mobility, FPV camera operations, sound module creation, and is capable of being programmed to execute complex tasks such as motion tracking. This means that the *S1* is a robot vehicle that can be used to follow a dance instructor or performer's movement pattern around in an environment both automatically and by manual controls. The tracking options and mobility of this technology allow for continuous viewing of a dancer's body as it moves through space. This enables dancers to move more freely when either recording themselves, teaching online dance classes, or performing for theater or film productions without the worry of dancing outside of the camera's video frame. The device produces videos with sound that can be saved, played back, and shared; which can present further explorations of the movement. The *RoboMaster S1* software also encourages dancers to become more knowledgeable in interdisciplinary skills such as engineering (building robots) and programming (applying computer code and gestural maneuvers). This promotes dancers to become more digitally literate and better communicators when collaborating with tech infused creative works.

After assembly, the robot vehicle was modified by incorporating the *DJI Osmos Action* camera with voice control, for additional video recording options that provide a higher quality picture resolution than the robot's onboard digital camera. With the addition of a smartphone and tablet as video monitoring systems, the completed robot unit was tested in a series of dance scenarios. Using the concept of multimedia learning theory, I devised an outline of dance and robot exploration that included five phases: The first stage was the process of building the robot. Second, I explored the usefulness of an electronic robot for dance education. Third, I taught dancers in a virtual (online) dance technique class. Fourth, I worked in-studio with dancers and the same robot on choreography and computer programming explorations. Fifthly, I experimented with the robot's use for single person creative works to further understand its autonomous attributes and functionality for dance practice.

Assembly

For the remainder of this discussion the *Robomaster S1* will be referred to as "Charlie". Charlie is made up of 100 high quality components and I was able to build it in 75 steps (see appendix for assembly details). I built Charlie to confirm or deny whether or not the steps could be accomplished within a 10-week regular dance course quarter and still have time to also learn dance technique or choreography. I began by assembling the omnidirectional wheels; which allows for signal transmission of movement in all directions. Next, I built Charlie's skeleton by fastening the chassis cover to the middle frame. I continued with the installation of the motherboard toward the rear of the vehicle. This component works as the nervous system of

Charlie, pumping electrical currents to each part of the robot system. Afterwards, four sensors were placed in the inner compartment of the chassis's front hood, rear trunk, and side door panels; then fixed to the frame and the cables were inserted into the motherboard. Once that was completed, I moved to installing the wheels to the frame. The gimbal unit was then tightened to the top of the frame and linked to the motherboard. Charlie's brain or intelligent controller was mounted on the top of the gimbal and synced by a data cable. In addition, an audio speaker was plugged into the intelligent controller and situated on the gimbal. The body was completed by enclosing the cables underneath with the chassis cabin cover.

Charlie's manufacturing design includes a laser and gel bead gun blaster for game use and competitive robot battles. However, I chose to negate this option and rather modified the space for this component with the *Osmos Action* camera, enabling the ability to film in 4K with voice control features such as "start recording", "stop recording", and "power off" to name a few. Lastly, the heart or intelligent battery is inserted from the back of the module, the power source button is pressed, and Charlie "comes to life". As actor Colin Clive famously said in his 1931 role as Dr. Henry Frankenstein: "Look! It's moving. It's alive. It's alive...IT'S ALIVE!"
https://vimeo.com/547792879

Operations

Charlie was programmed and controlled with the use of the *RoboMaster* app. After downloading the software onto my iPad, I connected to Charlie's intelligent controller via its embedded Wi-Fi signal, which activates the robot's online system. A series of calibrations for specific sections of the robot were performed to make sure the mechanics were functioning properly. This procedure included the prompting of addressing the motor, which relates to the correct rotational directions of each mecanum wheel. Striking each of the four armor plates is next, to address the detection and sensitivity of its LED light indicators. Once completed, I created my profile account and was sent to the main page of the interface. From this point, I was presented with a menu providing such functions as systems modifications, component status, connectivity icons, display options, gimbal settings, voice language selections, robot volume, video library, GPS information, solo mode, battle competitions, and the lab; which offered project-based courses that enhance users' understanding of programming languages, from robotics applications to AI technology, with different projects for both beginners and experts.

DJI's "RoboAcademy" provides a curriculum of videos and programming guides which I began to translate for dance students. Their in-depth videos introduce robotics in simple but fascinating ways for dancers, giving insightful and relevant scientific information. Through basic programming options, Charlie can perform AI autonomous actions such as person tracking, line following, gesture recognition, and sound response activations. Manually operating Charlie involved the use of two digital controls. One allowed for forward, backward, or sideward movement and the other rotated the yaw and pitch of the gimbal. Once I had learned the robot's maneuverability and programming options it was time to put Charlie to action. If I was creating a choreographic work, I would design the movement on my body and once I felt that I had enough material, I would then teach it to dancers. Working with Charlie felt like a similar process. https://vimeo.com/547739688

Testing

Charlie's technology was tested through a series of three dance educational scenarios that involved a) virtual class instructing, b) in-studio student experimentation, and c) on-site choreography, to explore multiple methods of merging student-centered learning with the use of technology.

A) Virtual Class - teaching classes online requires a constant awareness of staying in view of the screen for proper student or teacher viewing. The intent of this scenario was to explore the use of an autonomous robot as a video monitoring tool to enhance mobility as an instructor or student in a virtual dance class setting. Most online classes are experienced in the home environment, so my objective was to test the robot's tracking capabilities in a confined space. I implemented an additional mount fixed on the hood of Charlie, which would hold an iPhone that displayed the *Zoom* video conferencing platform.

After arranging my new home studio space, for the safety of Charlie, and assuring all devices were connected and working successfully, I introduced Charlie to 25 tap students in a UC, Irvine tap class. I began by reading Charlie's bio of capabilities. Dancers were fascinated and immediately inspired comments and questions such as: "Wow, where did you get that?", "how does it work?" As much as I would in a traditional dance technique class, I explained and demonstrated the functionality of Charlie's movement. The dancers instantly began discussing their possible uses for partnering with Charlie in their creative projects or practice. Once the excitement of imagining the options settled down, we began dancing. First, with a dance warmup, I used the motion tracking functions, its person identity mode, and through a green-gridded screen with a yellow rectangle box, It recognized my highlighted body. With a single tap of my finger, I enabled the gimbal to pan and tilt with slight movement of the wheels to accommodate wide rotations of the camera's gimbal arm; and a simple vocal cue of "start recording", Charlie began filming my movements.

As the class proceeded I switched to the person targeting mode, which unlocked Charlie's omnidirectional wheels. This function was activated by a double tap of my finger to my image in the *Matrix* style interface. I moved freely around my teaching space as Charlie followed my forward, backward, and sideways motion, as well as spins, curved lines, and circles. Lastly, I demonstrated a tap dance combination and the audio sound from my taps were recorded in real time through Charlie's speakers and stored as a recording file. Charlie's documentation of video and audio files could later be played back or that data could be manipulated and programmed with other devices. https://vimeo.com/547277394

B) Student Experimentation - this scenario involved two university dance students in a dance studio. The goal of this research was to discover how Charlie could be incorporated into the learning practices of dancers and how perceptive they are to the experience. The two students were not among the 25 tap dancers described in the above scenario. Once again, I began with a brief overview of how the robot was engineered and its artificial intelligent functions, then proceeded to give a live demonstration as both the performer and operator. This included showcasing Charlie's omnidirectional motion, person identity tracking, and object following modes. Then, one at a time, I synced them to the system's person targeting mode and had them develop a personal connection and relationship with Charlie through their interaction, movement, and imagination. Soon after and without being prompted to do so, the students enthusiastically assumed their desired roles and started exploring. The first technique I had the operator try was Charlie's solo mode, which gave the dancer full control of the wheels and gimbal motions. The performer, who chose to move in the style of tap, was asked to dance freely around the studio without focusing on the robot but still remaining aware of its presents so as not to damage the equipment. This section of the experiment focused on enhancing students filming techniques through videography, directing, choreography and even theatrical role playing.

As the trio became comfortable with one another's movement, I proceeded to instruct the operator to use Charlie's onboard intercom system to verbally direct the performer's movement, allowing for long distance communication without yelling. The dancer was then asked to start towards the far end studio and move according to the directions of the operator. Afterwards, the operator and performer roles were reversed and the exploration was repeated, note that performer number 2 selected a contemporary Irish jig movement as their style of dance expression. Finally, I had both dancers collaborate on programming a customized movement action of the robot by using the drag and drop, block coding software of *Scratch* and *Python*. A choreographed movement phrase was then created to complement the camera actions of Charlie. This involved both of the dancer's collaborative and problem solving skills in order to create a digitally designed performance moment. Their collaborative efforts were stretched even further when the dancers were promoted to explore Charlie's AI functions through improvisational dance and partnering.

During this process, vaccinations for Covid-19 were being administered around the world, and social restrictions were lessening. I began to question how universities would transition back to in-person dance classes and how I would continue to engage students in maintaining their dance training alongside their use of technology.
https://vimeo.com/544378793

C) On-Site Creative Work - many dance artists are presented with the task of filming themselves without the assistance of others. The premise of this scenario is to create a short screendance that was filmed completely autonomously. In this experiment, I designed an array of cinematic camera work (AI functions) for Charlie to execute with the help of the *Scratch* drag and drop block coding interface, and along with the key functionality of Charlie's person identity mode, which were experimented with in the previous scenarios, I explored the process of programming three AI actions that were then activated when filming certain scenes on site. The actions created were a gesture-controlled response that was coded to recognize my arms when held in the air in a V-shape. This signaled Charlie to perform two quick sideways movements followed by two v-shape diagonal motions as the gimbal panned up and down.

I then used line tracking capabilities by enabling its object recognition software to follow my pre-designed, hand-drawn patterns on the ground. I tested both of these techniques as a dolly track for capturing choreographed sequences. In my third programming cue of either clapping my hands or stomping my feet, Charlie creates 2 large circles in a sideways motion. This was achieved by first setting a code around the shape I wanted to design with specific movements for the chassis and gimbal. I then determined the number sounds (ie., claps and stomps) needed to generate the command and completed the coding.

This time, Charlie tested all of these programs in an outdoor environment. The outdoor filming was to see how durable and steady the shots would be while moving over rougher terrain such as concrete. Charlie was also placed in different locations to accommodate still-frame recording perspectives and b-roll footage.
https://vimeo.com/547336621

Chapter 3

<u>Findings</u>

Robotics for Dancers

Incorporating portable digital devices into a formal dance practice provided students and a dance educator with the fundamental information about real-time interaction with a robot, creating opportunities to design and structure movement phrases, explore options for documenting movement and audio, and gain a basic understanding of programming a robot as a potential dance partner. I found through my exploration that naming the device after assembly allowed me to create an interpersonal relationship with the robot. This experiment utilized many emerging technologies and expanded upon several aspects presented in my review of literature. From enhancing digital literacy through media applications, robotic interface choreographic design, and the incorporation of electric sensors, to AI technology, collaborative possibilities, and creative production, I found that these experiences allow student tap dancers to explore movement through interdisciplinary actions; such as the introductory skills of engineering and programming that they learned with the use of Charlie. Educational institutions working with portable digital devices suited with state-of-the-art technologies like the *RoboMaster S1*, enables dance practitioners, educators, and creators to unleash their imaginations and movement communicational skills through the use of a robust and low-cost hardware system that students or teachers can operate individually or collectively.

The engineering portion of building the robot proved to be one of the most beneficial components toward dancers' digital literacy. The fact that the robot came unassembled, allowed me to fully understand the mechanics and develop a kind of interpersonal relationship with the device and therefore named the robot, Charlie. Although the assembly took a great deal of focus to not miss crucial steps such as screws or data connections, it was necessary to understand whether or not assembly of an individual robot could be an individual or small group activity for dance students. The attention to detailing the robot promotes an active involvement of hand and eye coordination, the learning of a new language, and individual goal setting. An ability to modify Charlie with additional cameras and rigging systems encourages cognitive thinking and problem solving skills. Like learning dance, it's derived from the introduction of a combination of steps that leads one through a journey of purpose and creativity and the process could be an exciting experience for dance students, especially as a collaborative project.

Operating software applications and digital interfaces are a part of the majority of a dancers' daily routine. The *RoboMaster* app is a user friendly and engaging platform that entices the exploration of computer programming and movement communication with immediate results. Each interface page design transforms the learning of how to maneuver the robot, enable AI functions, and code into simple to execute tasks with a diverse range of gaming style control features, futuristic displays, and high tech sound effects. Based on my observation of dancers in scenarios A and B and my experience in scenario C, this creative approach to teaching and learning the use and functionality of digital devices is a perfect introduction for dance teachers and students to operating advanced technologies.

As I tested Charlie as a productive tool for formal dance classes, I also discovered some strengths and weaknesses in its ability to present a cohesive experience for student-teacher interaction. In experiment (A) the virtual class scenario, using Charlie as an autonomous video conferencing monitor for online university tap class, my findings were that the person identity tracking capabilities performed accurately, following my directional movement with ease. However, there were specific limitations and adjustments that proved to be challenging during the operation of a live class. For instance, a distance of about six feet was needed to successfully be recognized and stay connected to the tracker. Once the indicator lost signal, the process of repositioning oneself was necessary to maintain connection. I found that in a home setting, where space is limited, Charlie's single tap follow mode, which only allows sight motion of the wheel, but full access to the gimbal, was the most beneficial. Whereas the object target mode tracking system, which animates the full mobility of the chassis, was too sensitive in following my movement. With the distance restriction of six feet, Charlie would crash into the surrounding furniture as a result of moving in closer to the robot at times. In a dance studio, there would be less challenges of crashing into furniture. In addition, the height of the robot's body off the floor is low and the display showcases a high angular perspective; for tap dancing, its low camera views highlight the legs and feet, helping students see the articulation of the steps clearly. The mobility of the function would be a great asset for either instructors or students.

Experimenting with Charlie in the studio with students turned out to be a very successful observation of the collaborative implications of using portable digital devices for class exploration, as in scenario (B) of my methods. I found that as an instructor, modeling both the performer and operator roles first demonstrated to the students not only how it functions, but it provided an avenue for students to start mentally preparing exploratory implementations of its use. In a matter of minutes, both students showcased a high level of engagement, comfort, communication, and creativity. Utilizing Charlie as a teaching tool for capturing movement and dancing for the camera opened the doorway for introducing film production skills such as directing, cinematography, choreography, scene design, and teamwork. When working with the two dancers, I observed their growth in the ability to adapt choreography to benefit the productivity of the robot's activities, which expanded their ideas and initiated the designing of new opportunities within the studies of movement and the functionality of the technology; resulting in qualitative changes in movement.

The information from these experiences can be as general as developing a deeper understanding of the simple positioning of the body in space as it relates to the camera, or as complex as the programming of AI modules to produce in-camera special effects.

The only downfall I recognized was that to accommodate a classroom setting, multiple devices would need to be purchased. As witnessed in the history of digital literacy in dance, funding is of the utmost importance. So, making the idea that learning dance with technology is required as a pivotal component to its practice will increase its financial backing. Challenging the minds of dancers by incorporating technology prepares them for 21st century opportunities and perhaps, extensions of this type of technology will emerge from an open forum that creates a more affordable and accessible platform for institutions to customize and use for their specific dance program needs and budget.

The success of creating videos with Charlie is determined by the knowledge of the operator. In the case of scenario (C) of my methods, both operations and performance were executed by one person. First, one drawback of the robot is that its camera and software is not designed for extensive video recording. Rather, the technology works more as an eye to identify subjects and interact. Its video library only stores 10 clips, one-minute long. This limitation was also observed during scenario (A) recording of tap sounds through the intelligent controller's audio speaker. For this reason, it was imperative to modify Charlie with a secondary camera capable of documenting extensive video footage in high quality. As far as using the self programmed AI functions in the field worked well with recognizing the choreographed motion and sound cue, as well as its capacity to follow line designs on the ground, especially over smoother terrain such as the wood and marley flooring associated with dance studios and theatre stages. When used as a solo device for filming movement, finding alternative camera angles to present a diverse selection of shots was cumbersome at times. Due to its weight and mobility, finding a solution to accomplish higher viewing perspectives took investigation. This may demonstrate to dancers the awareness of location scouting, on-site research, and improvisation as it relates to camera operations. In addition, the use of a technology such as Charlie, as a secondary recording device, for specific view points enhances its practicality for creative dance works.

The experience of my autonomous exploration has led to the conceptual development of a university curriculum for performers entitled *Robotics for Dancers.*

This 10 week course would consist of:

- Week 1 - Introduction to Robotics and Equipment
- Week 2 - Engineering through Robot Assembly
- Week 3 - Robotic Interface and Operations
- Week 4 - Programming AI Technologies
- Week 5 - Solo Mode: A Dancer/Robot Interpersonal Connection
- Week 6 - Collaborative Explorations
- Week 7 - Film Production Techniques
- Week 8 - Creative Project Development
- Week 9 - Creative Project Work Session
- Week 10 - Showcase of Creative Work

By creating an introductory course in dance and technology, I believe students can develop invaluable life skills that are transferable into other aspects of life. Like Merce Cunningham, I value a safe, exploratory, yet challenging learning environment where students feel comfortable enough to take chances and push past their limitations. In the age of virtual learning and the use of portable digital devices and other technological platforms, I found, even in this limited research project, that various teaching strategies are necessary to encourage digital literacy. The above approach also builds teamwork, gives each student a shared sense of responsibility, builds communication skills, increases their talents, and prepares dancers for 21st century dance-technology opportunities.

As dance educators adopt methods of teaching movement by implementing digital technology into the classroom, it will provide up-to-date subject material, encourage the engagement of technological possibilities for the advancement of the art, and demonstrate support for digital literacy as an essential tool for the development and longevity of creative endeavors.

Conclusion

As dance and technology combine and continue to influence one another, the need to educate dancers in the mechanics and programming of multiple technologies is of the utmost importance. Many are gaining experience working virtually, by using digital means of creating and developing new approaches to using computers to further research our understanding of movement. Independently, artists have furthered their own knowledge of technological involvement by continuing to create tech-infused works, providing dancers with hands-on experience, new knowledge in digital capabilities, and an expansion of the imagination.

Dance educators have a responsibility of helping students to expand their intellectual, creative, and technical perspectives of dance artists by enhancing their ability to inform audiences and peers of how boundaries can be broken, doors can be opened, and perspectives changed through the use of technology. We must encourage the adoption of new skill sets that journey beyond traditional dance techniques to enhance the execution of creative works. The modern operations of dance have furthered the necessity for students to become digitally literate. Therefore, preparing performing artists for a more successful collaboration with technology involved projects in the future. This furthers the need for trained dancers to be educated with digital literacy as a cohesive mode of their practice to increase opportunities and longevity within the field. It is important that students have opportunities to explore, discuss and evaluate what online sources will support their dance training from the aesthetic, technical and social media perspectives. As discussed in the previous pages of this research, digital media and devices play significant roles to students as it relates to dance education, entertainment, and as inspiration to those who have goals of working in the commercial industry. Building educational curriculum structure and community infrastructure around dance and digital literacy that serves 21st century artmaking are important for future practitioners and educators, especially for those who want to engage worldwide. Therefore, training dancers with technology requires a concentrated integration with curriculums.

Discovering what portable devices are suitable for dance purposes is one thing and recognizing its contributions to dance is another. As dance leaders and mentors, we must take an active role in incorporating technology as tools of the now. This means educators have their own journeys of discovery as it pertains to researching, experimenting, and teaching new knowledge of this ever evolving technological world. The ease of resourcing information in today's society is due to our digital flexibility. The state of living has dramatically altered dance and what is paramount to the execution of work. The field of combined mindset in dance is global, technological, collaborative, and creative due in great part to the expansion of the digital repertoire. So, a dance curriculum that emphasizes movement with digital literacy, is of the utmost importance for the advancements of creative minds and this multidisciplinary art form.

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Appendix

Project Video-Link Archive

- Assembly - https://vimeo.com/547792879
- Operations - https://vimeo.com/547739688
- Test: Scenario A - https://vimeo.com/547277394
- Test: Scenario B - https://vimeo.com/544378793
- Test: Scenario C - https://vimeo.com/547336621

Robot Engineering Info.

Assembly

- Each wheel is a unit and was created by hand with the use of 12 mecanum rollers, gel grease, ring bracket, inner and outer threaded hubs, and connected with a M4-A Screw.
- The front axis module base is attached to a x-shaped shaft cover and axis cover, then screwed to the middle frame.
- One of the first sets of data cables that was connected to the motion controller were the four hit detector sensors that were inserted into the motherboard's CAN BUS Port.
- Installation of the wheels was accomplished by connecting a motor mounting plate, M35081 brushless motor, ESC, and threaded mecanum wheels screwed to all four corners of the chassis. Its corresponding wires were strung through the underbelly of the vehicle and fed into the M BUS Port.
- The flex positional gimbal unit was then tightened to the top of the frame and linked to the CAN BUS Port.
- A camera with a ¼-inch sensor and 5 million pixels, allowing for a first person point of view perspective (POV) with a 120 degree field of view (FOV), was adjusted to the head of the gimbal.
- The body was completed by enclosing the cables underneath with the chassis cabin cover, and sealing the motion controller compartment with its transparent cover.
- Through the use of a flexible monopod, action camera accessory clip, and ball tight bungee cord; I balanced the *Osmos Action* camera in place, while making

sure to maintain clearance and not to exceed the weight limit of the gimbal for full mobility.

Project Equipment List

Robomaster S1

- Intelligent Controller - Using a powerful CPU, the Intelligent Controller can simultaneously support functions such as low-latency high-definition image transmission, AI computing, and programming development. It also coordinates transmission seamlessly to execute command signals
- 2-Axis Motorized Gimbal - The gimbal's yaw/pitch rotation range is 540° × 65°, offering an expansive field of view for the FPV camera. The built-in direct drive brushless motor works together with the IMU and advanced algorithms to allow gimbal movements with a vibration control accuracy [1] within ±0.02°, delivering smooth image transmission and a precision control experience
- Mecanum Wheels - The S1 comes with four Mecanum wheels, each with 12 rollers that allow omnidirectional movement and precision control. Front axes suspension allows for added versatility during operation
- High-Performance Motor - The S1 comes with a customized M3508I motor that features an integrated FOC ESC with an output torque of up to 250 mN•m. Linear Hall-effect sensors with advanced algorithms allow closed-loop control for added precision. Additional safety mechanisms deliver outstanding stability
- Software - The S1 supports Scratch and Python programming languages allowing users to experience math, physics, and AI technology, and coding in an easy to learn, educational platform. Additionally, with Scratch and Python interfaces for the speaker module, you can add musical notes to the action or even write a song for your S1 to play during sessions

Osmos Action

- Camera - Dual screen (front and back) hyper-responsive displays combined with (EIS) Electronic Image Stabilization
- Voice Control - Five vocal commands for essential functions like filming, capturing photos, and powering down the device
- Still Photography Modes - Single, Countdown, Timed, Burst, and AEB

- Video - 4K, 2.7K, 1080p, 720p – 240, Slow Motion, HDR Video, and Timelapse
- Connection - Wi-Fi and Bluetooth Frequencies
- Software- DJI Mimo

Computers

- Smartphone - Apple iPhone Pro
- Smart Tablet - Apple iPad Pro