Chapter 6
Reimagining the Audience-Dancer Relationship Through Mobile Augmented Reality

Patrick Pennefather
https://orcid.org/0000-0002-1936-1872
University of British Columbia, Canada

Claudia Krebs
University of British Columbia, Canada

Julie-Anne Saroyan
Small Stage, Canada

ABSTRACT

The research and development of an augmented reality (AR) application for Vancouver-based dance company Small Stage challenged a team of students at a graduate digital media program to understand how AR might reinvent the audience-dancer relationship. This chapter will chronicle the AR and choreographic development process that occurred simultaneously. Based on the documentation of that process, a number of insights emerged that dance creators and AR developers may find useful when developing an AR experience as counterpart to a live dance production. These include (1) understanding the role of technology to support or disrupt the traditional use of a proscenium-based stage, (2) describing how AR can be used to augment an audience's experience of dance, (3) integrating a motion capture pipeline to accelerate AR development to support the before and after experience of a public dance production.

DOI: 10.4018/978-1-7998-3669-8.ch006

INTRODUCTION

An increasing number of contemporary dance artists, choreographers and dance producers are integrating mobile technologies to create an experience of dance that appeals to the needs of emerging audiences. Sharing our experiments and explorations will advance our use of different technologies to extend the experience of the performative to a multiplicity of physical and virtual stages. The case study presented in this article depicts the use of Augmented Reality to interconnect an outdoor public event with a before and after experience. The creation of mixed realities, may lead to a different conception of an artistic creation that resonates with new audiences, who want to engage with our work in different ways.

CHAPTER OVERVIEW

This chapter will present a review of some technological methods that have supported proscenium-based contemporary dance works and those that have attempted to disrupt them. In the first part of the chapter, we underline how the traditional use of the proscenium more than any other type of stage, in dance and other performance traditions has informed how dance is seen. Choreographers, dance makers, producers and videographers have used technology in creative ways but most continue to perpetuate a separation between audience and dancer. In the second part of the chapter, we review early performative initiatives that have disrupted the distinction between audience and dancer, and how these have inspired the integration of technology to generate new types of audience interactions. In the third part of the chapter we detail the emergence of 3D capture technologies that have allowed dance creators to think of dance and dancer from multiple perspectives. In the final part of the chapter we describe an Augmented Reality (AR) research creation process that integrated the motion capture of dancers in order to present a 360-degree perspective, informed by a consideration of the before, during and after experiences of a public dance event. The integration of an AR application proposes an interconnected dance experience encompassing physical and virtual interactions useful to dance creators who want to draw new audiences to engage with their art in different ways and through multiple perspectives.

INTRODUCTION

Our use of Augmented Reality (AR) was motivated by a need to engage and in some cases re-engage emerging and often neglected audiences who want to "[engage] in the

arts differently." (Cohen 2013). We aspire to offer opportunities for those potential audiences who are not necessarily "walking away from the arts so much, but walking away from the traditional delivery mechanisms". Emerging audiences are interested in engaging interactively with dance and dancer beyond the typical venues where dance is produced. It may be beneficial for dance-creators to understand how technology has supported the popular *delivery mechanism* of proscenium-based performances. Equally beneficial will be to gain deeper understanding of less familiar initiatives that provided audiences with multiple perspectives of dance, in some ways more resonant with *theatre in the round* staging. For those interested in experimenting with different technologies when considering collaborations with software developers in the creation of interactive work that reimagines the audience-dancer relationship, the descriptive AR application development process in the second section of the chapter might also be useful.

TECHNOLOGY TO ENHANCE THE PROSCENIUM-BASED STAGE

While contemplating the use of emerging technologies like Augmented Reality (AR) to reimagine audience interactions with a performance, we need to understand two inter-connected forces. The first and most influential informing how dance is perceived, is the traditional staging of dance and other art forms including theatre that continues to dominate the performing arts scene; a perspective that creates a clear distinction between performer(s) on stage and a captive audience watching them. The second is how contemporary dance forms have been captured and represented through a variety of different media including photography, film, video, 360 video, and sensor-based technologies.

The Enduring Influence of Proscenium-Based Performance

When Isaac (1971) wrote the *Death of the Proscenium Stage*, chronicling the replacement of late 19th Century proscenium stages with early cinemas, he does not reflect on the similarities that both mediums proposes, particularly in terms of the constructed separation between an audience and what that audience watched. The relationship most dance creators have envisioned in the past two centuries when devising choreography is well described by Strindberg, where performers "are integrated into a three-dimensional physical and imaginary space behind the proscenium arch, considered as an immanent unit, and spectators are conceived as voyeurs peeping through a keyhole" (Imre, 2005, p. 44). Figure 1 below depicts a typical proscenium based stage, as opposed to a thrust stage with audiences on

Figure 1. The proscenium arch above the stage in Chicago's Auditorium Building. *Adapted from United States Library of Congress's Prints and Photographs division, JW Taylor, photographer, 1887.*

either side of the stage, or theatre-in-the-round, a more rarely used type of stage that the audience surrounds.

To provide captive audiences with increasingly enhanced 'keyholes', the development of technology in the performing arts has been informed by the evolving arts of stagecraft for different types of stages (scenic design, costume, lighting, props, sound, video and projection). Over the years, and influenced by cost, expertise in operation, and how reliable different technologies have been, some technologies have been integrated into regular use while others have faded into obscurity. While projection seems to have become common to many productions, sensors that allow dancers to trigger audio-visual cues, projection mapping, Augmented Reality (AR) and Mixed Reality have yet to become mainstays. These are still exploratory technologies that for a number of reasons have not yet become persistent in use. An early example of augmenting dance performance with projection reveals experiments

by Alwin Nikolais "well known for his dance pieces that incorporated hand painted slides projected onto the dancer's bodies on stage" (Brockhoeft et al., 2016, p. 398). The work of Nikolais is significant as it points to early experimentation of projecting two dimensional images onto the dancer's body. This, as opposed to its more common usage throughout the 20th century of projecting pre-rendered static or video images "behind performers on stage to create the illusion of interactivity" (p. 397) or to create environment, location, mood and historical period. The idea of integrating projected two dimensional objects, scenes and/or characters onto the real-world of the stage using any combination of screen, scrim, curtain, walls, set pieces or the stage itself as projected surface is common to dance and other performance traditions. The use of projection to augment performance has evolved to allow creators to *map,* or position specific projected images onto a variety of different shaped surfaces including actors. Projection mapping was first used in productions like Sondheim and Lapine's musical *Sunday in the Park with George* (1984). That evolution has included experimentation with the technology of interactive spatial AR (Wellner, 1991) that uses cameras to track the interaction of a performer with a projected image or video mapped to specific objects (Beira, Carvalho, & Kox, 2013; Clay et al, 2014; Lee et al., 2015; Bokaris et al., 2020). Sparacino et al. constructed "an interactive stage for a single performer [that allowed technicians] to coordinate and synchronize the performer's gestures, body movements, and speech, with projected images, graphics, expressive text, music, and sound" (p. 2). The Dance and Engineering in Augmented Reality (DEAR) collective demonstrated the capacity for AR to augment performance. They used "live scenes using visible projection of media onto dynamics surfaces in the real world" (Korostelev et al., 2011) and allowed dancers to have real-time interaction with moveable panels. Most concerted efforts over the years by dancers, choreographers, producers, film makers and technology developers, have been focused on creating experiences that support the performers' world on the stage behind the proscenium. Those impulses continue to delineate a boundary between the performer on the stage and audiences who have been trained to observe at a distance, "subject to strict behavioral regulations [sitting] silently and undisturbed in the darkness of the auditorium" (Imre, 2005, p. 44). While dance has been presented on thrust stages offering front and side views of a performance, the prevailing contract remains; an audience receives what a performer projects. Even difficult to locate dance performances within theatrical productions on theatre-in-the-round stages abide by the same established division. Some theatre productions that integrate choreography within a production seem to engage more in faking "an in-the-round feel by modifying a proscenium theatre, either using a thrust or adding seats onstage" (Snook, 2015). Regardless of the desire to erode or make vanish the fourth wall however, creators integrating different types of technological innovations in different venues have at times had to accept the affordances and

constraints of a proscenium, informed by the complex computational tasks upon which the performers and performance depend. Emerging technologies to enhance stagecraft need to be operated from a low-risk controlled environment and need to be consistent in their own performance. A rule of play with performance is that if a technology is not stable and threatens the staging of a work, then it will not be used no matter how astonishing.

Capture Technologies and the Reinforcement of the Audience-Performer Dichotomy

The influence of proscenium-based dance has directly informed how dance has been captured and presented to viewers on different types of screens. Most technological advances in this capacity have, since the early days of Edison, Muybridge, and others been applied to replicate the proscenium view of dance for a viewing audience that does not need to do much to watch. This is evident in early attempts to 'capture the dance' in order to experience it through pre-recorded 'keyholes'. Eadweard Muybridge's Dancing Woman (1887), shows one of the earliest attempts to capture the motion of a dancer using Chronophotography (Figure 2), a method that was used to rapidly photograph successive phases of motion using multiple cameras, in effect slowing down the dance to its frame by frame representation. In Figure 2, we notice the perspective of the dancer that epitomizes a similar proscenium-based perspective.

Figure 2. Woman Dancing (Fancy): Plate 187 from Animal Locomotion.
Adapted from Museum of Modern Art, New York City, USA by Eadweard J. Muybridge, 1887

Muybridge demonstrated that the everyday motion of typical human activities could be dissected into a series of stills. When pieced together with a zoopraxiscope

or other mechanical device, a moving representation of all those captured images was displayed. Since that time, the representation of dance has evolved through a variety of different types of 'keyholes'. Screens, mediating the live dancer have included photography, film, television, projection on a multitude of surfaces, computer monitors, tablets, mobile devices and head-mounted displays (Virtual Reality (VR) and Mixed Reality (MR) devices). With the exception of experimental dance films and some music videos presenting dance artists in different types of locations (warehouse, beach, industrial wastelands), with close-ups on different body parts, as part of a narrative journey, and using all types of visual effects, the dominant use of film and video continues to present full-bodied dancers from a front perspective and on a proscenium stage, with all energy focused by a performer to the camera representing a seated audience member. Despite advances in technology, as early as the turn of the 21st Century, Dixon (1999) writes of dance's transposition to computer screen, commenting that "the computational proscenium returns drama to its traditional roots within a fixed box frame" (p. 138). In that same year Merce Cunningham's Biped (1999), used a process of "optical motion capture devices to record the moving bodies of dancers". These were transferred into digital 3-D representations, manipulated, and finally the dancers performed along with the projected animations" (Capristo, 2012) on a proscenium-based stage. While viewers may be afforded different viewing angles of dance and a variety of locations through the lenses of Virtual Reality, the dancer is shot from the front, maintaining either a proscenium or thrust perspective offering 180-degree video. If an VR user looks behind or too far left or right they will only see black. Case Western Reserve University's dance production (Robinson, 2017), offered audience members head-mounted displays (Microsoft's Mixed Reality Hololens) to observe and augment live dance on a typical proscenium stage. While compelling from the point of view of creating a hybrid MR experience, the audience relationship with the dancer transpired through a more modernized head mounted *keyhole*. The Hololens offers users a limited field of view when superimposing virtual images onto the real world. The depiction in Figure 3 while not precisely correct in the percentage of the image that can be seen, gives an idea of the area a hologram might occupy when looking through the lens onto the real world.

Leveraging technology to change stagecraft but not straying too far from the traditional convention of enhancing the performance for a captive audience seems to be a common recurring theme. This is why the persistent reinvention of audience-dancer relationships leveraging technology does not necessarily result in a new audience experience. To understand how to engage audiences differently, we would benefit from knowing some of the experiments that artists have engaged in, in opposition to the audience-performer relationships that proscenium-based stages reinforced, and how these forged new interactions regardless of the technology used to do so.

Figure 3. Small Stage Canadian National Arts Centre touring shot courtesy of Small Stage 2017

DISRUPTING PROSCENIUM-BASED PERFORMANCE

The separation between audience and performer has been challenged across the arts and has been well-documented for over a century. Clowns, pantomimes, vaudeville and cabaret performers, have led the charge, often engaging in behaviors and interactions that disrupt the boundaries of the proscenium. Early 20th Century inspirations, like Brecht's dialectal theatre motivated a variety of artists across culture, time and performing traditions to experiment with breaking the fourth wall, usually by actors engaging audience members in dialogue, re-arranging the set in front of an audience, disregarding the boundaries between stage and audience, and blurring the line between the world in the play and the world outside of it by disrupting narrative flow. The resurgence of theatre-in-the-round stages in 20th Century North America, like Seattle's Penthouse Theatre (1940), proposed a new type engagement with an audience in 360, offering them multiple perspectives of the same staged play. The breaking of the fourth wall has been instigated in film, as early as McLane's (1918) silent film *Men Who Have Made Love to Me*, many of the movies by Stan Laurel and Oliver Hardy during their Roach era (1926-1940), addressing the viewing audience from both silent and spoken movies, and the antics of Charlie Chaplin in *The Great Dictator* (1940), as if present in the viewer's current reality. Although pantomime and mime traditions have experimented with breaking the divide between stage and performer, the early emergence of dance creators disrupting the proscenium convention is not as well-known historically. We can trace early experiments that may have fueled the courage required to disrupt audience

expectations from impresario Diaghelev's Ballets Russes, and choreographer Nijinsky challenging ballet convention in league with Stravinsky (1913). Indeed, if a riot did in fact occur on May 13th, 1913, it was a combination of events that challenged the convention of ballet itself, if not through audience/performer relationship, then definitely through challenging norms and expectations of what an audience should expect in the theatre. A combination of "strange, stamping movements and awkward poses defied every canon of gracefulness" while "Stravinsky's score for *The Rite of Spring* contradicted every rule about what music should be" (Hewitt, (2016). The disruption of the audience-performer relationship seemed to thrive, however, predominantly in non-conventional theatrical environments whose staging, such as black box theatres afforded new interactions. These included what we might categorize as site-specific locations nowadays such as restaurants, pubs, community halls, churches and any number of public indoor and outdoor spaces, in addition to mobile theatre initiatives tasking audiences with moving around several sites to experience the work.

When New York critic Anderson (1974) commented on the typical context of experiencing a dance performance where "one is always conscious that the dancing is happening behind the proscenium arch; the proscenium arch, in fact, serves very noticeably as a picture frame", Trisha Brown (Floor of the Forest, 1970, and Roof piece, 1971) had already begun challenging the idea of the proscenium by removing it as an obstacle, transporting dancer and audience to site-specific locations where dance could be experienced from different sight lines. Pina Bausch was another dance artist "acclaimed for breaking through the fourth wall, having her dancers intrude on the people in Row A, shake their hands, [and] ask them for money" (New Yorker, 2002). Another early pioneer in this regard, was Forsythe, particularly with Ballett Frankfurt (1980-2004) where his company persistently broke the fourth wall and blurred the lines between audience and performer. In his later work in art galleries (1991-2018), he deconstructed ideas of what constituted a show. Still relevant since its first appearance in 1999, contemporary Israeli choreographer Ohad Naharin attempts to break the fourth wall with "Minus 16" (Ballet BC, 2017): at the end of the performance, dancers bring audience members on stage and perform with them, effectively eliminating the boundaries between observer and observed, between performer and audience. This participatory approach can provide a more immersive experience for those audience members brought onto the stage. Managing the conventions demanded of creators in typical proscenium based theatrical venues, dance creators like Naharin attempt to disrupt the 'picture frame' of the stage that divides audience and performer, by breaking that fourth wall and in so doing offering audiences a less formal and different perspective of dance.

Disrupting the Traditional 'Picture Frame' of Dance With Technology

Nowadays, and more than ever before, dance producers have access to affordable and ubiquitous technologies and non-proscenium site-specific spaces allow new relationships with audiences. There exist some documented disruptive experiments that are worth mentioning. One example occurred as early as 1966 in a staging of Steve Paxton's Physical Things, a collaboration with engineer Dick Wulf (Valverde 2004, as cited in Risner & Anderson, 2008, p. 114). Paxton tasked audience members to provide the sound score that cued dancers in terms of duration and phrasing (p. 114), by manipulating audio devices that created different sounds "dependent upon the audience member's movement" (p. 114). New genres of artistic hybrid creations integrating postmodern dance forms and film in the late 20th Century, have contributed to the erosion of dance being associated solely with the live proscenium stage. More recently, the ubiquitous nature of the internet has opened the opportunity for "dancers from different locations to perform for live audiences in real time across time zones" (Parrish 2007, p. 1383). As Brockhoeft et al. report "interactivity in performance can even extend past the artist's control and be given to the audience" (p. 398). The author's recount the work of Toenjes and Reimer (2015) and their Laboratory for Audience Interactive Technologies that tasked "audience members…to download an application to their phones [allowing] them to directly impact and interact with the show changing certain visualizations or triggering cues". Small Stage's 'Jukebox' installation at the Fun Palace: Carnival of Mixed Realities (2019) offered audiences the opportunity to co-curate short dance works before they were presented interacting with a host to choose from a selection of audio, projected images, lighting and dance. At the same event, some audience members were ushered into a secret booth where they were challenged to maintain focus on a Burlesque dancer through a window as they were bombarded with text messages. The moment audience members turned their attention to the iPad in front of them, the dynamics and emotion of the dance would shift, often resulting in the dancer leaving the staged booth disappointed. Offering different types of interactions on different types of stages to audiences have afforded multiple perspectives of dance. Virtual Reality platforms like Facebook, YouTube and Google are experimenting with placing the user at different places on the stage to view live performances and presentations from various locations and perspectives. VR also offers performative potential. One example is the installation *Eve, Dance is an Unplaceable Place* by Margherita Bergamo and digital artist Daniel González Franco, centered around a contemporary dancer wearing a VR headset who draws in spectators to interact through touch. The pioneering work of fourth wall disruptors paved the way for increased opportunities to look at dance in a different way. The growth and popularity

of computing technologies and with it, access to and increasingly affordable 3D technologies have inspired dance creators to experiment with representing a dancer in three dimensions, stripping bare the typical front view perspective of the dancer.

CAPTURING MOTION IN THREE DIMENSIONS

Beyond the contestable '3D'ifying' of dance on a typical 2D screen, and the longer history of 3D animation of dance, which once relied on the animator's ability to recreate pre-recorded film and video of real dancers to inspire motion, more recent technologies such as motion capture have proposed a different type of reframing. Motion capture is an "animation technique [that] measures a dancer's position and orientation in three dimensional space in real time, while recording the data in a computer" (p. 125). That data includes "location, speed, duration and various movement qualities" (p. 125) often as part of an interactive system (Naugle, 2001, 2006).

It offers an alternative to merely representing the dance in two dimensions through traditional video capture. In its early application in dance, motion capture was predominantly explored as a utilitarian tool in order to support the choreographic process, in the archival of work and the ability to recall choreographic sequences from a 3D perspective. Experiments in motion capture began more than 30 years ago with internationally recognized New York based choreographer Bill T. Jones. Ghostcatching represented dance in a more abstract way using motion capture and fusing "dance, drawing, and computer composition" as a digital art installation (Jones, Kaiser and Eshkar's (1999). Integrating motion capture into a live dance performance, Jones commented that motion capture "may change the dancer's predicament de rigueur by invigorating a self they didn't know they had" (Dils, 2002, p. 95). The dancer's perspective of themselves is augmented, observing their motion from multiple angles they are no longer a two dimensional representation of self. The same is true for the viewer's perspective. As Risner and Anderson (2008) write "the audience–performer relationship is expanded from a one-sided conversation into a dialogue" (p. 49). Motion capture has evolved dramatically over the years with innovations in performance capture inclusive of facial and finger capture, as well as different types of capture systems. There have been incredible developments across media, from video games to 3D animation. In terms of the use of motion capture in performative settings, capture and tracking techniques have been experimented with on a live dancer wearing a motion capture suit, in order to represent them as another type of character, projected on a screen to a live audience. Meador et al.'s (2004) interdisciplinary creation experimented with "dance performance featuring live-motion capture, real-time computer graphics, and multi-image projection"

(p.1). Meador's team were experimenting with new audience-dancer relationships, allowing audiences to experience the dance in a variety of real and virtual formats simultaneously. Clay et al.'s (2014) innovative work "explored 3D stereoscopy as a display technique for augmented reality and interaction in real time on stage" (p. 21) using an xSens motion capture suit with seventeen sensors mapping the joints of the body. While the performance was presented in a traditional proscenium-based stage at least attempts were made for virtual content to 'reach out' to audiences wearing 3D glasses. Beyond the use of motion capture in the live staging of dance, we were interested in using the technology to create a new type of dancer. That dancer could have meaning beyond the confines a proscenium-based stage, their traditional 2D passive representation on a screen, and could be accessed by anyone with a mobile device.

A CASE STUDY OF AUGMENTED REALITY APPLICATION DEVELOPMENT

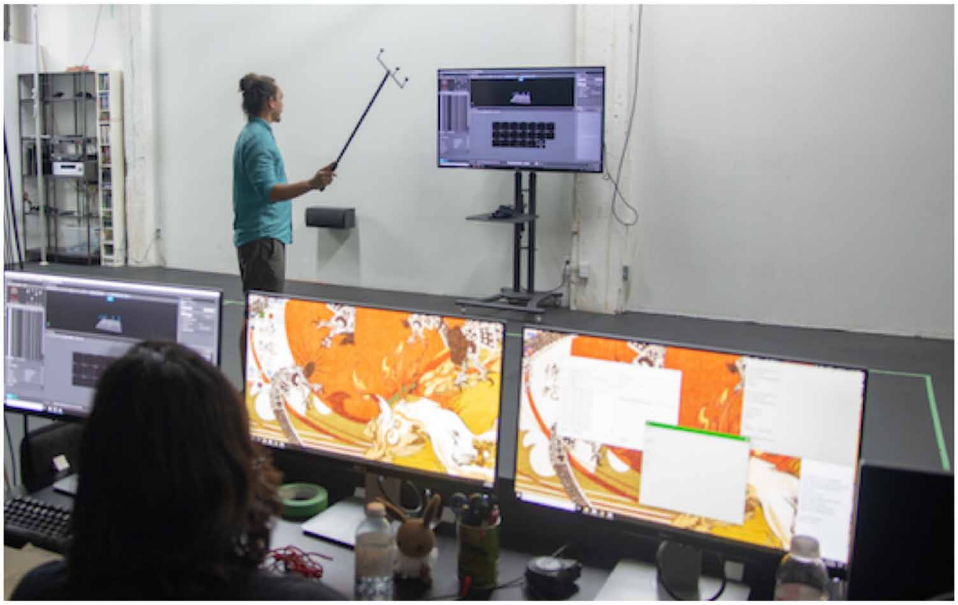
For reasons of affordability and increased access, marker-based augmented reality applications on mobile devices offers dance creators and software developers familiar development pipelines that may accelerate technological integration. Knowing this, and having knowledge of the traditional audience-dancer relationship, and the context in which that relationship has been reinforced, the goal of the AR application project was to investigate new potential interactions through the use of augmented reality in an outdoor public space. Small Stage, a dance production company dedicated to experimenting with and producing public engagement with dance, wanted to explore how AR dancers could complement a series of summer dance productions in an outdoor venue. This part of the chapter will discuss the development of the AR application as a case study by: 1) describing the parallel development of the AR application and the choreographic process for the live outdoor event; 2) present the investigation as a case study and; 3) detail evolving research questions.

Designing for AR While the Dances Were Created

In most design processes there is a phase dedicated to ideation, brainstorming and exploration and while the tools to achieve this may be different, a similar process occurs in the development process of modern dance. A choreographer and/or dance creator develop material in a rehearsal space, source music, conduct research into the underlying story, theme, inspiration, in order to generate ideas that will support their choreographic creation. Part of the ideation phase of the development team consisted in working with dancers while the choreography was still in development.

Rather than working with a completed choreographic routine, the team was presented with four dances-in-progress consisting of small sections, exploring initial ideas and sequences that were under a minute in duration. To accelerate the virtualization of the dance sequences to be used in a marker-based AR application, the development team enlisted an established motion capture studio.

Figure 4. The Sawmill Motion Capture Studio by Sean Conroy 2018



Motion capture was thought to speed up the process as time would be saved animating movement since the studio would also provide an existing rig, and initial clean-up of the captured data. The animation team was introduced to Motion Builder software in order to fine tune the rig, preparing it for animation within Maya and import into the Unity 3D game engine. These sequences were rehearsed prior to bringing them to the studio for capture. The dance producer, acted as a bridge between the physical and digital worlds persistently considering how the AR motion captured dance might fit into the live dance production itself. All elements of the live choreography, AR software development and the integration of the physical and the virtual co-existed in a prototypical phase; each influenced by the other.

Case Study Research

An increasing number of scholarly texts have surfaced that document the iterative experimentation of AR with dance (Franz et al., 2016; Clay et al., 2012, 2014; Sparacino et al., 1999), in order to detail the process, or discuss the parallel development of a dance production along with the emerging technology that supports that live production. Context-specific emerging technology development is difficult to replicate as each case study is informed by the vision of the choreographer and in-the-moment decisions of the development team in terms of how they will integrate art with design and programming, and what they believe they will be able to co-construct. While the MDM team was being mentored with the development of the AR application by supervisor and the Small Stage team, inquiry into the design process was not focused on investigating a pre-determined occurrence of a phenomenon in a controlled environment. Research was aligned with Case Study research, originated by Stake (1982) whereby a number of phenomena are explored in context and assertions made are specific to the context in which research is conducted generating naturalistic generalizations "as a product of experience" (Stake, 1978, p. 6). In the Small Stage case study, an intentional design approach was not possible. Transparency about the uncertainty of how the AR application would eventually be integrated within the live dance production kept the development and choreographic teams open to all possibilities. The research process complemented that of many live dance productions; a shifting pendulum between an intention to have our audience experiences pre-defined, and the acceptance that audiences will interpret the meaning of our work however they might.

Evolution of Research Questions

Research questions that guided the development team evolved from being concerned with the application development process to an increasing concern of the user experience. That focus allowed the team to identify an idealized hybrid user/audience member who might: 1) be interested in attending the outdoor dance event, and 2) have exposure to an AR application before, during and after the live dance work. With an initial focus on development we began with this question: *How can a motion capture pipeline be integrated into augmented reality dance application for a live production*? The team quickly realized the answer to this question had already been proposed by many developers, artists and scholars through a variety of publications (Parrish, 2007; Alaoui et al., 2013; Clay et al., 2014). Motion capture (MoCap) can save time for animators when it comes to rigging and developing a sequenced animation. In relation to the representation of dance virtually, it is important to note that MoCap had its own limitations, predominantly based on a limit of a 15-joint

skeleton that the capture of motion was rigged to. Capturing the articulation of the fingers on the hand, for example has been a persistent historical challenge in the MoCap field that is still in progress despite advances in glove sensors. Beyond the MoCap pipeline and how it might accelerate a 3D visualization of choreographed dance, the software development team needed to understand how the virtual dancer in the AR application would be inter-connected with the live dance. Collaboration with Small Stage afforded us the opportunity to persistently consider the integration of the physical and virtual worlds of the production. An AR app offered very specific affordances and constraints including representation and accuracy of movement, and how it would fit in to the larger scale live dance production. The following research question became more central to the investigation reflecting a greater integration of both the development and choreographic process: *How can an AR dancer inter-connect audiences to the live dance experience before, during and after a series of performances*? Answering this question with Small Stage allowed all of us to better understand the role of the virtual dancer within the bigger picture, which, was to exist within an independent mobile application that users could access before, during and after the public performances. It also helped to scope what we could do in the limited time period of three weeks, the technologies that would be employed, and what we needed to have ready for application to be publishable as it would be downloaded prior to the live event. In addition, Small Stage's mandate to engage the public compelled the software development team to identify a hybrid audience/user: an audience member experiencing the physical reality of the dance around them and the virtual one experienced through some type of screen. *What new interactions and experiences would an AR dance application offer audience-goers before and after an outdoor dance production*?

INSIGHTS FROM THE AR APPLICATION DEVELOPMENT PROCESS

Several insights emerged from the development of the AR dance experience and its integration in the vision of the live Small Stage production. These include recommendations to: (a) redefine notions of audience by decomposing their entire experience, (b) identify and design for usability through persistent user-testing of the AR application; (c) design audience experiences before and after the live dance event; (d) inter-connect the virtual and real dances and dancers through the use of motion capture; (e) experiment with the representation of a live dancer in the virtual, and (f) leverage an integrated AR experience to propose new audience interactions.

Redefine the Audience/User in Context

Designing for users is a familiar process in many software development processes but the language tends not to be used in live performance traditions. We refer to the humans that engage with our interactive applications as users and those who watch a typical dance show as an audience. When creating dance for traditional proscenium-based audiences the interaction points are not that complex. Most of the time the audience is seated, quiet and well behaved. The dancer's responsibility is to offer their craft and project their performances to a seated audience usually positioned in front and on either side of the dancer. Lighting is pre-determined and called as a series of fixed cues. Music, whether live or pre-recorded is also cued. While some choreographers encourage and expect dancers to improvise to music, they are usually familiar with the musical form as they would have rehearsed with it prior to the performance. When it comes to reinventing the audience-dancer relationship during a person's before, during and after experience of an outdoor dance event, it will benefit us to identify multiple types interaction points with that dance; each audience member experiencing the dance performance from a different perspective simultaneously. In the process we combined choreographic, performative and technological languages to define a new type of inter-connected performative and mediated experience. Some audience members began their journey as mobile AR users prior to experiencing the live dance event, and others after they finished watching the performance. All those who downloaded the application would have a memento of the event in virtualized form, that they could interact with anywhere and anytime they wished. We also needed to understand potential features the application would offer that would inspire people to download and use the application.

Identify and Design for Usability

Human-centered design tools common to application development such as user-experience driven prototyping were central in the user experience design. The AR process integrated a user-centric approach centered on identifying usability issues that the AR audiences might have with a mobile device, when used as a complement to an outdoor dance performance. User-tests gave the team insights on the development environment (Unity 3D), operating system, how to design interactions in outdoor lighting conditions, the look/feel representation of the dancer, accuracy of motion as reflected in real-world dance, integration of music, best type of physical marker that would trigger the AR dancer, duration of the experience, size of virtual dancer in relation to screen size, and more. Testing for usability intersected many times with the intended audience experience the team designed for. As an example, remaining true to the intent of reinventing the audience-dancer relationship, the team chose a

360-degree view of the dancer. This design decision challenged the convention of a virtual dance contained solely within a 180-degree proscenium or thrust view. This design decision allowed audiences viewing the live production to also access the virtual dancers through the AR application and watch excerpts of the dance from whatever perspective they chose.

Design Audience Experiences Before and After the Live Performance

As the development team more closely understood the AR audience's possible journeys, they reflected on the design and identified two major interaction points; before and after the live performance. At the onset of the project, Small Stage was unsure of whether or not the application would be published. Identifying why we wanted audiences to interact with the application prior to experiencing the live dance production challenged the MDM team to design a scalable prototype that the Small Stage team could eventually publish and offer to their extensive audience base. Part of the reason to rapidly prototype an AR application was an identified need for audiences to have access to the application ahead of a performance, in order to give them a glimpse of what the live production might be like. As Small Stage made clear, access to the free application ahead of time also became a marketing tool to offer to existing followers and to attract new types of audiences to attend the live event. This is somewhat related to initiatives being taken by other dance creators turning to "Viber chats, vlogs and Periscope live streams to give audiences an honest look into their lives" (Ouelette, 2016). In the case of Small Stage, for those unable to access the live event, the application was a strategic method of inclusion and access. Spontaneous street walkers who might not have known of the AR application nor the dance production ahead of time were also identified by Small Stage. These types of users inspired Small Stage to activate the AR application in a pre-show talk pointing audiences to printed QR codes in the surrounding area that linked to the Google Play and Apple Store. Once the connection between the virtual and physical worlds of dance was forged, audiences knew that they had an application to take home with them; virtual dancers as a memento of the live production. AR audiences could use the business card size Small Stage markers to trigger a reminder of the real dances anytime they wanted. During the post-show experience audiences that formed after the performances had already begun, were guided to download the application and "take the dancers home" in between each work. While the application was primarily designed with a before and after experience in mind, the performances created an opportunity to regularly introduce new audiences to the application, extending the number of downloads and creating new Small Stage followers in the process. In this way the live event increased the opportunity for audiences to experience the

AR application and the AR application introduced potential users to the experience of the live dance production.

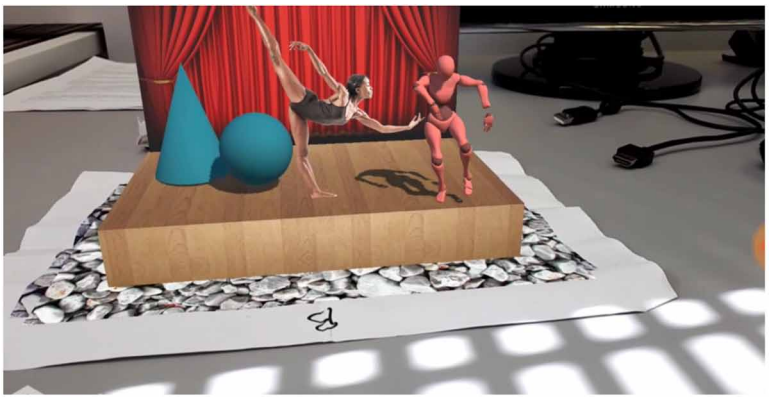
Inter-connect the Virtual and Real Dances and Dancers Through the Use of Motion Capture

The use of motion capture afforded a powerful mimetic tool that functioned to inter-connect the gestural vocabulary common to both the virtual and the real dances. If AR audiences experienced the virtual dancer prior, they would then be able to see recurring movement patterns and through motion effects of water and fire, connect each dance to specific elements. If AR audiences experienced the virtual dancer after, they would have a virtualized version of what they had just seen to keep and re-trigger, show friends and to remind them of the real world dance experience.

Experiment With the Representation of a Live Dancer in the Virtual

Tempting as it was to use a generic rigged human model to convey the captured motion of each dancer, the team, guided by Small Stage, discovered that it was far more interesting to leverage a variety of Unity particle effects to convey meaning that reflected the inspirational themes of the Elements (water, fire, air).

Figure 5. First prototype of AR dance shows more traditional representation of dancer and stage with front view limitation by Sean Conroy, 2018

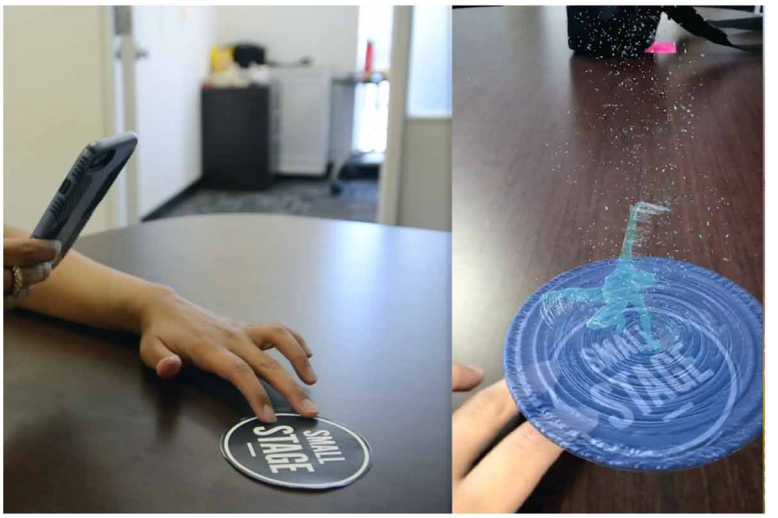


In doing so, AR audiences were exposed to a version of the dance that was not trying to simply emulate or provide references to the live performance. The AR

dances were an artistic work by themselves, similar in the gestural vocabulary of the live dances, yet different enough to stand on their own.

Leverage an Integrated AR Experience to Propose New Audience Interactions

Figure 6. (overleaf) AR application in use showing a rotatable stage placed on a table viewed from above of a particle effected dancer by Sean Conroy, 2018



The choice to use AR as a key part of the entire audience/user experience for the project afforded the opportunity to disrupt a more traditional perception of the project solely being perceived by audience/user as similar to a typical proscenium-based experience. While the site-specific nature of the Small Stage production also contributed to that disruption, the virtual dance in its 360-degree perspective introduced our hybrid audiences to an entirely different way to experience dance. Unlike a traditional performance, the AR audience was transformed into co-curator. There were a number of ways in which this was achieved. First, they chose the angle of view through which virtual dance was seen as compared to having little choice when viewing a staged live performance. Our co-curators could also experiment with the distance of the phone from the marker, shifting the dancer's dimensions, getting a close-up look at the details, and experiencing the virtual dance with any real-world background they wanted. The AR audience was provided more points of interaction than simply watching a dance performance. While the AR dance

consisted of a triggered routine and the screen between the virtual dancer and AR audience could be interpreted as a new type of proscenium, the virtual dance could be seen anywhere, from a lying, seated or standing position and on any surface. Audiences could pause the dance, observe it from different angles in 360 degrees. This reinvented relationship with live dance and virtual dancer provoked the AR audience to experience an inter-connected dance production in a completely different way; one not constrained by time or place.

CONCLUSION

Regardless of what technology offers in conventional or innovative performance environments, there has been and may always be an ever-present tense relationship between technological innovation and the way that modern dance is performed, presented and experienced. The use of emerging technology to support live dance productions offers creators opportunities to generate new audience-dancer relationships. For dance to be experienced free from the constraints of the proscenium, dance creators need to continue a tradition of disrupting expectations for audiences who may have become complacent in how their experience of dance has been designed. The augmented representation of a dancer in 360 engage an audience differently and transforms the how we consider the stage, performer and audience. Our emerging audiences are a kind of newly empowered co-curator who can now create the stage, summon the dance at their convenience and superimpose it in three dimensions onto any real-world surface. They can decide where, when and how they want to experience or re-experience parts of a choreographed routine they found memorable. An augmented reality dancer adds to a transforming landscape of dance. Through this case study, the process of capturing dance using motion capture was instrumental in accelerating the pipeline, and provided Small Stage with a living choreographic record of the process itself. Equally important, the intentional use of AR as a critical component of a live dance experience created a new performative ecosystem that bridged the real and the virtual, and engaged the public in a new way. Launched with Small Stage's outdoor Summer Series, the application interconnected audiences to the dancers in the real world. With the combination of an outdoor site-specific production of dance staged as theatre-in-the-round and an augmented perspective of a dancer free from the constraints of a proscenium-based perspective, a new inter-dependent dance event was prototyped and tested offering an experience of dance accessible to both older and newer generations of audiences.

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