The Experience of Physical and Social Presence in a Virtual Learning Environment as Impacted by the Affordance of Movement Enabled by Motion Tracking

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THE EXPERIENCE OF PHYSICAL AND SOCIAL PRESENCE IN A VIRTUAL LEARNING ENVIRONMENT AS IMPACTED BY THE AFFORDANCE OF MOVEMENT ENABLED BY MOTION TRACKING

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Modeling and Simulation in the College of Engineering and Computer Science at the University of Central Florida Orlando, Florida

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Major Professor: Charles E. Hughes
ABSTRACT

This research synthesizes existing research findings that social presence (sense of connection with others) and physical presence (sense of being there) increase learning outcomes in Virtual Learning Environments (VLEs) with findings that traditional motion tracking of participants wearing head mounted displays in virtual reality increases both physical and social presence. This information suggests that motion tracking in mixed reality VLEs has a positive impact on social presence and on physical presence. For this study, the affordance of free movement among virtual objects is enabled by Microsoft Kinect tracking of the user’s position that is translated to movement of the virtual camera to simulate user movement and proximity to elements of the virtual environment.

This study used a mixed method, multimodal approach including qualitative, subjective, objective, and physiological data to measure social and physical presence. The testbed for this research was TLE TeachLivE™, a mixed reality classroom populated with virtual students. The subjective measures are 1) modified Witmer and Singer Questionnaire and 2) Social Presence Instrument (Bailenson, 2002b). The objective measure is a literature based Social Presence Behavioral Coding sheet used to record frequency of occurrences of factors of social presence. Finally, the physiological measure is heart rate as recorded by the MIO Alpha.

The primary contribution of this study was that the hypotheses that the affordance of movement in a mixed reality classroom has a positive impact on user perception and experience of a) physical presence and b) social presence in a VLE were supported. This hypothesis was supported in all three measures. The secondary contribution of this
research is the literature based Social Presence Behavioral Coding. The final
contribution of this research is a research framework that integrates subjective, objective,
and physiological measures of social presence in one study. This approach can be
applied to various user experience research studies of various VLEs. Finally, in addition
to general alignment of the physiological, objective, and subjective measures, there were
anecdotal instances of factors of social presence occurring simultaneously with increased
heart rate.
To Taylor and Jasmine-

Anything I can do,

you can do!

I love you.
ACKNOWLEDGMENTS

I would like to thank my family, especially my daughters for the sacrifices that they endured of my time, attention, energy and industry during this process. Thanks to my family members and friends who, in addition to helping me keep up with my real world responsibilities, have also been my counselors, cheerleaders, editors, research assistants, and occasional chauffeurs during this process.

Thank you to my parents and grandparents who instilled and reinforced a mantra that education was the key to success in life. I must give special thanks and honor to my mother, whose wisdom resounded, “Knowledge is power” and whose aspirations and accomplishments have guided my way and still serve as a northern star to my dreams.

Thank you to my dissertation chair and mentor, Dr. Charles E. Hughes who could always see where I was heading before I got there. I would also like to thank my dissertation committee members, Drs. Bailenson, Dieker, and Marino who have inspired and guided me, while also patiently enduring my search for self-actualization through research. I would also like to thank the TeachLivE team for allowing me into the inner circles of technological innovation at its finest and allowing me to use the virtual classroom simulation to support my research objectives.

Finally, I would also like to acknowledge Bill & Melinda Gates Foundation, whose gift, in part, supported the TeachLivE team, my Ph.D. dissertation study, and the execution of this study.
# TABLE OF CONTENTS

LIST OF FIGURES................................................................................................................................. xii

LIST OF TABLES............................................................................................................................................ xiv

LIST OF ACRONYMS (OR) ABBREVIATIONS.............................................................................................. xv

CHAPTER ONE: INTRODUCTION..................................................................................................................  1

1.1 Need for the Study.................................................................................................................................. 1

1.2 Research and Scope Statement of the Problem....................................................................................... 5

1.3 Purpose of the Study............................................................................................................................... 8

1.4 Training the Elements of Effective Teaching......................................................................................... 9

1.5 Research Questions............................................................................................................................... 10

1.6 Contributions......................................................................................................................................... 11

1.7 Thesis Organization............................................................................................................................... 11

1.8 Definition of Terms............................................................................................................................... 12

CHAPTER TWO: LITERATURE REVIEW...................................................................................................... 16

2.1 Advances in VR Technology ................................................................................................................ 18

2.1.1 Visual Displays............................................................................................................................... 19

2.1.2 Motion Tracking in Virtual Environments..................................................................................... 20

2.2 Importance of Fidelity.......................................................................................................................... 21

2.3 Trifurcation of Presence: Physical, Social and Co-presence............................................................... 22

2.3.1 Physical Presence.......................................................................................................................... 24

2.3.2 Co-Presence..................................................................................................................................... 25

2.3.3 Social presence............................................................................................................................. 26
| 2.3.4 Factors of Social Presence                                                                 | 33 |
| 2.3.5 Confounds to Understanding Social Presence                                           | 41 |
| 2.4 Measuring Physical Presence, Co-presence, and Social Presence                          | 42 |
| 2.4.1 Measuring Presence                                                                    | 43 |
| 2.4.2 Challenges to Subjective Measures of Presence                                        | 44 |
| 2.4.3 Measuring Social Presence                                                             | 45 |
| 2.4.4 Triangulating Presence                                                                | 47 |
| 2.5 Distinguishing Virtual, Mixed, and Augmented Reality as Simulation                     | 49 |
| 2.6 Learning in VR/AR/MR Simulations                                                       | 51 |
| 2.6.1 Effectiveness of VR/AR/MR in Education and Training                                 | 53 |
| 2.6.2 Learning and Training Theory                                                         | 53 |
| 2.6.3 After Action Review (AAR) in Simulation                                               | 53 |
| 2.6.4 Importance of Interpersonal Connection for Learning                                  | 54 |
| 2.6.5 Intersection of Engagement, Involvement, and Psychological Immersion                 | 54 |
| 2.7 Experiential Learning in Simulations                                                    | 55 |
| 2.8 TLE TeachLivE™                                                                       | 56 |
| CHAPTER THREE: PILOT STUDY 1                                                                 | 61 |
| 3.1 Education Constructs Evaluated                                                         | 61 |
| 3.1.1 Specific Praise                                                                      | 62 |
| 3.1.2 Wait Time                                                                          | 62 |
| 3.1.3 Higher Order Questioning                                                             | 63 |
| 3.2 User Experience Measures                                                               | 63 |
| 3.2.1 Qualitative Presence and User Experience: Interviews                                 | 63 |
| 3.2.2 Qualitative User Experience Measure: Observation                                    | 64 |
3.2.3 Quantitative User Experience: Questionnaire ................................................................. 65
3.3 Mixed Methods Approach ...................................................................................................... 65
3.4 Case Study Methodology and Results .................................................................................... 66
3.5 Findings from Case Study ...................................................................................................... 67
   3.5.1 Does the experience of TeachLivE effect learning outcomes? ..................................... 68
   3.5.2 Do people using TeachLivE experience presence? ......................................................... 68
   3.5.3 Are participants suspending disbelief in TeachLivE? .................................................... 69
   3.5.4 Do students experience immersion in TeachLivE? ......................................................... 70
   3.5.5 Interaction between presence, immersion, and suspension of disbelief ....................... 70
3.6 Pilot One Discussion ............................................................................................................. 71
   3.6.1 Qualitative Findings from Interviews .............................................................................. 72
   3.6.2 Questionnaire Findings .................................................................................................. 72
3.7 Conclusions from Pilot 1 ...................................................................................................... 73

CHAPTER FOUR: PILOT STUDY 2 ................................................................................................. 74
4.1 Specific Constructs .................................................................................................................. 74
4.2 Learner Population Characteristics ...................................................................................... 75
4.3 Learning Measures .............................................................................................................. 76
4.4 Procedures / Research Approach ......................................................................................... 76
4.5 Experimental Conditions ..................................................................................................... 77
4.6 Pilot Two Apparatus and Materials Used in Experiment .................................................... 77
4.7 Pilot Two Instruments and Supplies ..................................................................................... 77
   4.7.1 Delivery .......................................................................................................................... 78
4.8 Pilot Two Results .................................................................................................................. 78
4.9 Pilot Two Discussion ........................................................................................................... 79
CHAPTER FIVE: METHODOLOGY AND PROCEDURES

5.1 Research Questions .................................................................................................................................................. 83

5.2 Research Design ........................................................................................................................................................ 84

5.2.1 Empirical: Behavioral Measures: Coding Sheet ................................................................................... 85

5.3 Constructs .................................................................................................................................................................... 85

5.4 Participants ................................................................................................................................................................ . 87

5.4.1 Preparing the Participants ........................................................................................................................... 87

5.5 Instruments and Supplies ...................................................................................................................................... 88

5.5.1 Behavioral Coding Sheet as Instrumentation ....................................................................................... 88

5.5.2 MIO Instrumentation ...................................................................................................................................... 90

5.5.3 Social Presence Questionnaire as Instrumentation ........................................................................... 90

5.5.4 Modified Witmer and Singer Presence Questionnaire ........................................................................ 91

CHAPTER SIX: RESULTS ..................................................................................................................................................... 92

6.1 Data Screening ........................................................................................................................................................... 92

6.2 Description of Statistics for the Sample ........................................................................................................... 92

6.3 Comparing Means: Movement Condition T-Tests ....................................................................................... 94

6.4 Heart Rate Reports ................................................................................................................................................... 95

6.5 Triangulation .............................................................................................................................................................. 97

6.6 Summary of Qualitative Data ............................................................................................................................... 98

6.6.1 Qualitative Feedback Related to Social Presence ............................................................................... 98

6.6.2 Qualitative Feedback Related to Movement Condition ................................................................. 101

6.6.3 Qualitative Feedback Related to Fidelity and Realism ................................................................. 102

6.6.4 Qualitative Feedback Related to General Experience ................................................................. 104

6.6.5 Qualitative Feedback Related to Heart Rate ...................................................................................... 104
LIST OF FIGURES

Figure 1 Virtuality Continuum ........................................................................................................ 49
Figure 2 Traditional classroom teacher interaction Vs. TeachLivE virtual classroom ................. 57
Figure 3 Proximity in traditional classroom vs proximity in TeachLivE classroom simulator .... 58
Figure 4 Teacher movement not tracked so view is always front of class ................................. 60
Figure 5 Teacher movement is translated to virtual camera movement ................................. 60
Figure 6 Teacher in front of class ............................................................................................... 69
Figure 7 Teacher view leaning down to talk to student ............................................................... 69
Figure 8 Condition 1 -- Static Display Heart Rates ................................................................. 97
Figure 9 Condition 2 - Movement Afforded Heart Rates ......................................................... 97
Figure 10 Participant 2 Heart Rate – IV Level 1 ..................................................................... 128
Figure 11 Participant 4 Heart Rate IV Level 1 ........................................................................ 128
Figure 12 Participant 6 Heart Rate IV Level 1 ........................................................................ 128
Figure 13 Participant 7 Heart Rate Graph IV Level 1 ............................................................. 129
Figure 14 Participant 8 Heart Rate Graph IV Level 1 ............................................................. 129
Figure 15 Participant 16 Heart Rate Graph IV Level 1 ............................................................ 129
Figure 16 Participant 15 Heart Rate Graph IV Level 1 ............................................................ 130
Figure 17 Participant 16 Heart Rate IV Level 1 .................................................................... 130
Figure 18 Participant 18 Heart Rate Graph IV Level 1 ............................................................ 131
Figure 19 Participant 1 Heart Rate Graph IV Level 2 .............................................................. 131
Figure 20 Participant 3 Heart Rate Graph Level 2 .................................................................... 132
Figure 21 Participant 5 Heart Rate Graph Level 2 .................................................................... 132
LIST OF TABLES

Table 1 Endogenous and Exogenous Factors of Social Presence ................................................. 34
Table 2 Factors that contribute to Social Presence ....................................................................... 41
Table 3 Rating of Realism of Virtual Students ............................................................................. 71
Table 4 Ratings of Realism of the Virtual Classroom ................................................................. 71
Table 5 Social Presence Behavioral Coding Sheet ....................................................................... 89
Table 6 Gender Breakdown of Participants ................................................................................. 92
Table 7 Age Breakdowns .............................................................................................................. 93
Table 8 Self-reported Ethnicity Breakdown ............................................................................... 93
Table 9 Self-reported Computer Usage ...................................................................................... 93
Table 10 Qualitative Feedback Related to General Experience ................................................. 104
# LIST OF ACRONYMS (OR) ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AAR</td>
<td>After-Action Review</td>
</tr>
<tr>
<td>AMITIES</td>
<td>Avatar-Mediated Interactive Training Individualized Experiences System</td>
</tr>
<tr>
<td>AR</td>
<td>Augmented Reality</td>
</tr>
<tr>
<td>AV</td>
<td>Augmented Virtuality</td>
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<tr>
<td>CVE</td>
<td>Collaborative Virtual Environments</td>
</tr>
<tr>
<td>EBP</td>
<td>Evidence-Based Practice</td>
</tr>
<tr>
<td>HIVE</td>
<td>Highly Immersive Virtual Environments</td>
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<tr>
<td>HRSD</td>
<td>Heart Rate Standard Deviation</td>
</tr>
<tr>
<td>ISPR</td>
<td>International Society for Presence Research</td>
</tr>
<tr>
<td>MOOC</td>
<td>Massively Open Online Courses</td>
</tr>
<tr>
<td>MR</td>
<td>Mixed Reality</td>
</tr>
<tr>
<td>ReflectLivE</td>
<td>TeachLivE Reflection System</td>
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<tr>
<td>VE</td>
<td>Virtual Environment</td>
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<tr>
<td>VLE</td>
<td>Virtual Learning Environments</td>
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<tr>
<td>VR</td>
<td>Virtual Reality</td>
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CHAPTER ONE: INTRODUCTION

1.1 Need for the Study

The field of education is evolving, with 6.7 million college students reporting to take at least one course online (Allen & Seaman, 2013). Educational Technology, including products such as digital books, serious games, simulations, and virtual classrooms, is a multi-billion dollar industry (Booker, 2013). When it comes to understanding how to maximize learning in technology mediated means and environments, the stakes are high with the myriad of potential approaches that may lead to success or potential failure.

Researchers have noted the need for study that has been generated by the rapid emergence of novel technologies and the applications of the various interfaces. These developments have resulted in changes to the landscape of education, in which standards of practice are being redefined as measures of effective teachers. According to the National Center for Educational Statistics, attrition rates are high for teachers while the quality of education received by students is on the decline (Bang, Kern, Luft, & Roehrig, 2007; Hussar, 2007). Simultaneously, the meaning of “classroom” has expanded dramatically to include areas inside of and outside of the traditional brick and mortar schoolhouses and college campuses (Berge & Clark, 2005; Jaggars, Edgecombe, Stacey, 2013; Miron, Urschel, 2012; Parker, Lenhart, Moore, Pew, & American Life, 2011). In addition to the influx of students in K12 education taking courses online, the number of
college students taking at least one online course increased to 7.1 million in 2013, representing a 6.1 percent increase from 2012 (Allen & Seaman, 2014).

An explosion of online learning and VLEs (e.g., Massively Open Online Courses (MOOCs), Khan Academy, Florida Virtual School) has increased the relevance and necessity for research that investigates and maximizes the efficacy of these environments in both K12 and Adult Education. Further, the advent of MOOCs and the expansion of Virtual K12 academic programs have heightened the urgency for effective design, development, and evaluation of VLEs (Bhuasiri, Xaymoungkhoun, Zo, Rho, & Ciganek, 2012). Much of the research in traditional education and now in virtual education cites a lack of engagement and connection as a cause of attrition of both teachers and students. Some of this lack of engagement is attributed to the asynchronous nature of online education (Leong, 2013; Jaggars et al., 2013; Coy, Marino & Serianni, 2014).

Many traditional considerations for evaluating teachers and classrooms have been repurposed to evaluate the classrooms (VLEs) and teachers. “Understanding the impact of those school environments, parental participation, and school support on student achievement is critical to interpreting those academic outcomes” (Coy et al, 2014, 74). Scholars have extolled enhanced communication between teacher and student as a standard for improving delivery of instruction. These range from school administrators to professors, such as Deb Grossman of Harvard University College of Education when she said "…we spend so little time teaching people how to deal with resistance from students and just how to interact with them…” (Stanford, 2011).

Classroom communication and interpersonal connection have long been concerns in education, these issues extend beyond physical classrooms to computer-mediated
approaches to delivering instruction (Clarke, Dede, & Dieterle, 2008; Mason, 2011; Stahl, 1994). This shift in the context of education demands practice that adequately prepares instructors to be effective in the new VLEs. Findings in domain will inform educational administrators as they make decisions on allocations of their scarce specific resources. Specifically, this will inform how decisions to allocate time to the “soft skills” such as the delivery of instruction and behavior management, and student-teacher / parent-teacher communication. The focus of this research is to analyze the efficacy and effectiveness of various aspects of VLEs in these soft skills, helping to provide clarity for professionals tasked with choosing platforms and Learning Management Systems as K12 and adult education continue to evolve.

Computer based simulated classrooms conceptualized through iterations from the PLATO (Programmed Logic for Automatic Teaching Operations) Simulator in the 1960s and 1970s into the present with systems including SimSchool and TeachLivE (Fink & Brownsmith, 1975; Mahon, Bryant, Brown, & Kim, 2010; McPherson et al., 2011; Munro & Noah, 1980; Sawchuck, 2011). The derivations include web-based 3D virtual environments such as Cook School District and SecondLife, PC based applications including SimSchool (Gibson, 2008) and other lab-based environments (Girod & Girod, 2008) with motion tracking and large displays such as TeachLivE (Dieker, Straub, Hughes, Hynes, & Hardin, 2014; Hayes, Straub, Dieker, Hughes, & Hynes, 2013). These efforts to provide education and training have found that the elements that engage students at K-20 levels are the realism, fidelity, and authenticity of the experience (Johnson, Rickel, Stiles, & Munro, 1998). Recreating these elements in a controlled environment requires extensive collaboration, planning, and iterative design (Sawchuck,
Harteveld notes this succinctly in Triadic Game Design Framework (2011), "if we have poorly designed education games, we can expect games with poor learning effects" (p. 19).

Stakeholders in education, including administrators, teachers, students, parents, and society in general, will benefit from a clearer understanding of ways to maximize the impact of current and emerging technologies, such as VLEs. This understanding will yield guidelines that reveal and explain the return on investment for improvements to any part of these systems. In physical classrooms engagement has been linked to the retention and ultimate success of students (Foundation, 2010; Fredricks, McColskey, Meli, Mordica, Montrosse, Mooney, & Southeast Regional Educational Laboratory). For the purposes of virtual classrooms, presence and social presence describe that experience of engagement when it occurs in a virtual environment. While engagement is often cited as a key barrier to student success across levels and disciplines, immersive learning environments have been found to elicit engagement from children and adult learners, spanning majority or minority students across genders, socioeconomic groups, and ability levels (Marino, 2013; Loureiro & Bettencourt, 2011; McPherson, Tyler-Wood, McEnturff Ellison, & Peak, 2011). Cross-disciplinary research has identified fidelity, suspension of disbelief, and immersion tendency as constructs that are inextricably related to the study of presence (Andreasen & Haciomeroglu, 2011; Lisa Dieker, Hynes, Hughes, & Smith, 2008; Fink & Brownsmith, 1975; Mahon et al., 2010; Simonsen, Myers, & DeLuca, 2010). The pedagogical considerations of engagement and communication in VLEs may include considerations of presence, but, more specifically, they apply to the domain of Social Presence Research.
Simulation serves as a bridge for the chasm between the research and practice that often allows what scholars know about learning and technology to stay exclusively in the lab (Albert & Gundlach, 2012; Avramenko, 2012; Foundation, 2010). This discourse adds to the bridge between VR research and practice by exploring the “tangible” effects of social presence on outcomes from learning that occurs in a computer-mediated environment. This contribution addresses the myriad of concerns about transfer of learning from simulations to high stakes physical classrooms.

1.2 Research and Scope Statement of the Problem

This research begins by exploring the impact of motion control in a virtual environment, in which tracking participant movement in the physical world and translating that movement to the virtual camera movement a virtual learning environment simulates movement. This corresponds with research on teacher practices that indicate that highly effective teachers use proximity for classroom management and student engagement. This study continues by examining the role of physical and social presence in virtual environments and their relationship with teaching and learning. Next, the research delves into the literature related to how virtual classrooms, virtual rehearsal, and simulation have been used and their affordances. Finally, this research explores the established measures for physical and social presence (i.e. subjective, objective, and physiological) and the relationships between the approaches.

Simulation research has demonstrated that the level of authenticity of training in simulation increases the transfer of knowledge, skills, and abilities gained from that
training (Issenberg, Gordon, Gordon, Safford, & Hart, 2001). Communication research demonstrates that the majority of interaction (between 65 and 93 percent) between individuals, including students and teachers, is nonverbal (Frank Biocca, Harms, & Burgoon, 2003; Mahon et al., 2010; Mehrabian, 2008; Wood, 2009). Traditionally, practice of pedagogy has been aggregated with other “soft skills” accomplished through role-play, whereby teachers in training taught to peers acting as children of the target age group (Jones & Eimers, 1975; Simonsen et al., 2010). These skills are in dire need of improvement among teachers. Over half of the high-leverage teaching practices for effective teaching involve significant levels of interpersonal communication, such as delivering a lesson, interacting with colleagues, peers, parents, and administrators across gender, culture, and socio-economic differences (Ball & Forzani, 2010). Authenticity in a VLE has been used to enhance training outcomes in various training/educational simulators from medical to military (Smith, 2010). The approach to enhancing a VLE with authenticity also extends to the acquisition of interpersonal skills. Effective scenarios and interactions exemplify the depth of nonverbal richness inherent in social interaction (Hayes, Hardin, & Hughes, 2013). Researchers indicate that the frequency and fidelity of the practice can be expected to lead to effective application in the field (Lisa Dieker et al., 2008; Mahon et al., 2010). While traditional strategies of role-play are still being utilized for K12 teacher training, there is a contingent of practitioners propelling a movement to simulation for the effective training of pre-service teachers (Sawchuck, 2011).

While many theorists support the notions of Marshall McLuhan (McLuhan & Lapham, 1994) that life is experienced forward, but only understood in retrospect,
technology is advancing at a rate so fast that much of our uses are implemented and
discarded before the critical eye even evaluates them and before the process oriented
mind evaluates them. Objections to the use of simulation and serious games by
opponents include a fear that there will be little to no learning or transfer of skills to the
classroom, because “there is a fear that computers can’t appropriately capture the nature
of a person” (Petros Katsioloudis, personal communication, September 5, 2012). Lead
designer of SimSchool, David Gibson, expounds on this saying that the purpose of these
simulations is “not to replace traditional face-to face student-teaching,” but instead to
allow the future or current teachers “the ability to experience specific skill-building
lessons”. The problem is that it is unclear which tools are effective for what purposes,
and why for distance learning and VLEs.

The focus of this research is to identify contributors to the experience of social
and physical presence for participants who delivered a lesson to simulated virtual
students in the Virtual Learning Environment, TeachLivE. Teachers self-reported on
perceived social presence, perceived physical presence, and overall perception of the
experience. Additionally, data was recorded to rate observable social presence and
learning as demonstrated by improved performance. This data was used to explore
potential effects of social presence on learning outcomes in VLEs.

This research culminated with social presence being measured by physiological
data. The three methods of social presence collected in the study (subjective, behavioral,
and physiological) will be triangulated. Triangulation is an approach that uses multiple
approaches to exploring as a way to validate the findings (Bryman, 2012, p. 1). This
approach of triangulation will be applied to enhance the confidence of the findings in this study.

1.3 Purpose of the Study

The purpose of this study is to increase contextual knowledge of a hypothesized relationship between translating a participant’s tracked movement to the virtual camera movement in a virtual environment to simulate movement and the participants’ perceived sense of physical presence and social presence. Additionally, this study examines relationships between subjective, behavioral, and physiological measures of social presence in an effort to improve the validity of results from user experience research that includes these constructs.

Simulation has been found to be one of the most effective and prevalent ways to afford the learning by doing process of experiential learning espoused by Dewey (Aldrich, 2009; Dewey, 1933; Johnson et al., 1998). Using simulation, instead of “real time” practice in the actual environment, allows a controlled environment for consistent directed learning, feedback, and reflection. The value of pedagogical or andragogical practice in simulation can be distilled to a statement made by Vince Lombardi, “practice does not make perfect. Perfect practice makes perfect”. Focus on fidelity, authenticity, physical presence, and social presence can enhance the ability for a practice to be a perfect practice that can yield superior performance.
1.4 Training the Elements of Effective Teaching

Existing research demonstrates the importance of improving teacher performance in K20 education, particularly during the evolution of the mediums by which education is accomplished (Alvarez & Anderson-Ketchmark, 2011; Foundation, 2010; Kane, 2010). With over sixty percent of new teachers reporting that they feel unprepared for the classroom upon graduation, there are numerous programs designed to get them up to par with classroom management and other high leverage practices for effective teaching (Ball & Forzani, 2010).

While there are thousands of theories on ways to develop highly effective teaching approaches (pedagogy/andragogy), much of the education has traditionally been deployed in direct lectures in face-to-face physical classroom environments (Andreas, Tsiatsos, Terzidou, & Pomportsis, 2010; Gibson, 2008; Koc & Bakir, 2010). The TeachLivE classroom is a tool that focuses on teaching teachers by allowing them to practice through social interaction with simulated students (Lopez, Hughes, Mapes, & Dieker, 2012; Sawchuck, 2011). While research has been done on efficacy of the system, and on the perception of presence experienced by users of the system, levels of engagement with the system, and the perceptions of the interface, there is a void in information as to which of the elements make the system so effective (Hayes et al., 2013; J. Walker & Dotger, 2012; Z. Walker, 2012; Whitten, Enicks, Wallace, & Morgan, 2013). This dissertation is focusing on the social aspects, specifically social presence, as the center of the experience of learning from interacting with simulated virtual students.
1.5 Research Questions

Because the existing research on presence in TeachLivE began with a focus on presence and learning in the environment, the next questions move to a deeper analysis specifically addressing elements thought to enhance learning interpersonal communication competency, in particular, the constructs of physical and social presence. This dissertation focuses on the following questions to isolate some of the variables that research has suggested contribute to the learning that occurs in the TeachLivE environment.

In this study the researcher sought to identify if there is a relationship between users’ perceived physical presence and social presence and the use of motion tracking to control the virtual camera in the TeachLivE Virtual Classroom. The research also explores there a relationship between participant’s behaviorally demonstrated social presence, self-report of social presence in a VLE, and a participant's autonomic responses that demonstrate social presence in a VLE?

The quasi-experimental mixed method approach of this study synthesizes prevalent approaches to measuring presence, social presence, and the efficacy of virtual learning environments as detailed in the literature (Botella, Bretón-López, Quero, Baños, & García-Palacios, 2010; Patel, Bailenson, Jung, Diankov, & Bajcsy, 2006). This study includes performance improvement assessments, blind coder ratings of behavior, as well as qualitative observations and quantitative self-reports of perceived social presence.
1.6 Contributions

The approach of this dissertation is to build more connections between some of the existing constructs in the experience and efficacy of Virtual Learning Environments (VLEs). This is achieved by collecting quantitative data on learners’ experiences of social presence in VLEs from subjective, behavioral, and physiological measures and examining them for hypothesized relationships. Ultimately, this exploration intends to inform the technology development, the academy, and the education community about existing practices and about which elements enhance learning in VLEs. Specifically, this research seeks to clarify the instructional impact and subsequent value of social presence fostered in VLEs.

1.7 Thesis Organization

This dissertation begins by addressing the questions of the impact of user movement translated to virtual camera movement to simulate proximity on physical and social presence in virtual learning environments with a literature review and subsequent research. Initially the literature review in chapter two begins with what the existing body of knowledge has revealed in relation to the defined research. This includes the existing literature on physical and social presence, evolution of the construct of presence from telepresence to the multiple derivations of the term currently used that relate to the experiences of interpersonal communication in the virtual environment. This analysis leads into the review of the methods used to measure physical presence, social presence, and co-presence, covering the nascent research on this construct during the final two
decades of the 20th century. The review exposes the different environments in which presence has and can be measured, from the Physical World to the Virtual World, including both mixed reality and augmented reality as elements that impact approaches to defining and measuring presence. The literature review concludes with an overview of the gaps in the literature.

Chapters three and four summarize the findings from two pilot studies. This flows into the methods for the primary study reported in this dissertation. Chapter 5 explains the theoretical framework, instrumentation, participant pool, experimental conditions and data collection used to address the current research questions. Chapter 6 explores the findings of the study and chapter 7 concludes with a discussion of the findings and generalizations that may be made, based on the research.

1.8 Definition of Terms

After Action Review (AAR) Period of directed reflection that follows a training experience in a Virtual, Live, or Constructive Simulation. AAR sessions are used to reinforce desired behaviors and extinguish undesired behaviors.

Augmented Reality (AR) Experience in which the perception of the physical world is enhanced (or augmented) with virtual agents or virtual entities, where the background context is physical and the virtual elements are part of the foreground.
Augmented Virtuality (AV) Experience in which real entities are placed in a virtual context; here the real elements are in the foreground and the virtual context is the background. AV can be considered the flip side of AR and vice versa.

Avatars All types of representations of an individual in a virtual environment (e.g. human surrogates, embodied agents, virtual humans)

Computer Mediated Learning Environment

Environments created in computers and delivered to users through various computer interfaces. This includes Virtual Learning Environments (VLEs), Collaborative Virtual Environments (CVEs), Highly Immersive Virtual Environments (HIVEs), virtual classrooms, mixed reality learning environments, and physical environments that are augmented by technology (e.g. Google Glass or a GPS on a mobile device).

Distance Learning Learning that occurs in which the teacher and the student are not co-located. This is often computer mediated, but historically referred to correspondence courses delivered by mail.

Engagement (Classroom) The state in which an individual is affectively, behaviorally, and cognitively involved with a classroom experience. This experience can be described in multiple
<p>| <strong>components, including attention, interest, physical</strong> |
| <strong>Engagement (Digital)</strong> The state in which an individual is affectively, behaviorally, and cognitively involved with a digital experience. This experience can be described in multiple components, including flow, immersion, physical presence, social presence, and motivation. |
| <strong>Flow</strong> An experience in which an individual experiences the merging of action and awareness, loss of self-consciousness, transformation of time, and enjoyment. (Csikszentmihaly, 1990). |
| <strong>Entity</strong> A virtual instance of an object portrayed in a virtual environment. |
| <strong>Mixed Reality</strong> A virtual environment that has elements of the physical world as part of the environment. Here the virtual and the physical are co-present with elements of each potentially appearing in the foreground, middle ground and background. This encompasses Augmented Reality and Augmented Virtuality but is often employed for the interval between these two in which there are multiple layers of real and virtual, each partially occluding each other as appropriate. |</p>
<table>
<thead>
<tr>
<th><strong>Motion Control</strong></th>
<th>Movement of a virtual camera controlled by dynamic real-time capture of a user’s location in a physical space.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social Presence</strong></td>
<td>The sense of being there with some perceived entity(s) with whom we are sharing an experience.</td>
</tr>
<tr>
<td><strong>Simulation</strong></td>
<td>Re-creation of a physical or theorized system. This may refer to live, virtual, constructive simulation or some combination of them.</td>
</tr>
<tr>
<td><strong>Physical Presence</strong></td>
<td>The perception of existing or “being there” in a physical environment (local or remote).</td>
</tr>
<tr>
<td><strong>Virtual Reality Environment</strong></td>
<td>An environment that is computer generated, this may be the simulation of a place that exists or of a fictitious place.</td>
</tr>
</tbody>
</table>
CHAPTER TWO: LITERATURE REVIEW

This review of the literature covers the evolution of presence research over the last thirty years and explores the current state of presence research. This review of literature continues to discuss the expansion of the relevance of the categories of presence for explaining the experience and efficacy of computer-generated environments as well as the subsequent distinctions of presence to include co-presence and social presence.

The term presence has evolved from its inception as a truncated version of ‘telepresence’ (Minsky, 1980; Steuer, 1992) to the nebulous construct with multiple meanings and subcategories from which many areas of research have been spawned. Initially, as described by teleoperators, presence expressed the sensation of being at the remote worksite rather than at the operator’s control station (Minsky, 1980). Over time, presence has been simplified to be “the subjective experience of being in one place or environment, even when one is physically situated in another” (Witmer & Singer, 1998, p. 1). As applied to a virtual environment (VE), presence refers to experiencing the computer-generated environment rather than the actual physical locale” (1998, p. 225). The pervasively accepted understanding of presence at that time was as the sense of “being there” (Witmer & Singer, 1998) or as Kim and Biocca (1997) framed telepresence, “being transported”. This idea was expanded to be bidirectional in 2000 beyond simply the sense of “being there” to also include the sense of the object being with the subject, or in other words, “being here” (Lombard). Also in 2000, the International Society for Presence Research (ISPR) published a more formal definition of presence as,
a psychological state or subjective perception in which even though part or all of an individual’s current experience is generated by and/or filtered through human-made technology, part or all of the individual’s perception fails to accurately acknowledge the role of the technology in the experience (ISPR).

Some scholars focus more on the idea that the state of presence is defined by a conscious sense of “being in the place specified by the displays” (Slater, Linakis, Usoh, Kooper, & Street, 1996, p. 3). While the nebulous idea of presence is in perpetual flux, the premise espoused by Minsky in 1980 is still central to the discourse. “Telepresence emphasizes the importance of high-quality sensory feedback and suggests future instruments that will feel and work so much like our own hands that we won’t notice any significant difference (Minsky, 1980, p. 1).”

Simultaneously, as the definition of presence has been simplified, the conversation on presence has made the concept more robust by adding various sub-constructs to presence such as: physical presence, spatial presence, co-presence, and social presence, social realism, transportation, immersion, social actor within a medium, and medium within social actor (ISPR, 2000; Matthew Lombard & Ditton, 1997). Some theorists have explored the complexity of these elements in their assertions on the evolution of presence, in which they refer to the sense of presence as “an evolved neuropsychological process, created through the central nervous system (Waterworth and Waterworth, 2008, p. 1)” . While this claim will require a great deal more research, the perspective is the underpinning of their assertion that this sense of presence involves how to “differentiate between the internal (the self) and the external (the other)” in computer mediated experiences. This sense of presence, they expound, enables the individual to
allow the technology to become part of the self. By relinquishing the cognitive processing capacity that would have processed the interface with the technology, the individual is then able to perceive and act as if they were an unmediated entity in the environment (Waterworth & Waterworth, 2008). This evolution of presence has moved the users of this technology to the place early theorists envisioned, in which the user can suspend their disbelief and experience immersion (Steuer, 1992).

2.1 Advances in VR Technology

The discourse surrounding both presence and social presence has progressed as the technology has advanced. Virtual environments allow users to experience a location other than the one that they are physically situated through a virtual, or computer generated, graphical, three-dimensional environment. The level of perceiving that one exists in the virtual environment as opposed to the one they are physically located is central to virtual reality (Witmer & Singer, 1998). Early iterations of this evolution can be seen through examination of the evolution of the technology.

The discourse that accompanied the nascent stage of virtual technology included teleoperators accessing remote work, yielding the understanding of telepresence and presence as the sense of being at the worksite instead of the control station where the operator was residing. With the advent of virtual environments, the zeitgeist shifted to apply concepts of presence to a virtual environment (VE). From this perspective, presence was said to refer to “experiencing the computer-generated environment rather than the actual physical locale” (Witmer & Singer, 1998). The experience of presence, or
the sense of being in the virtual space as opposed to the physical space in which one was actually located, has become more possible and relevant with the advancements, reduction in cost, and pervasiveness of the supporting technologies (Blascovich & Bailenson, 2011; M. Lombard, 2011). This outlook created the climate in which researchers highlighted degree of control, sensory modality, immediacy of control, anticipation of events, mode of control, physical environment modifiability, degree of movement perception, multimodal presentation, and environmental richness as factors that contribute to presence. In this time frame, scholars began to distinguish between presence and telepresence announcing that the terms should no longer be used interchangeably. Simultaneously, the distinction had still not been made between presence and social presence. This shift explains frequently unclear boundaries between presence and social presence, as the discourse was about the concepts already being developed before the division was drawn.

2.1.1 Visual Displays

Engelbart’s 1968 attempts to launch an oN-Line System (NLS) for collaboration among geographically dispersed partners from the Augmentation Research Center at Stanford Research demonstrated the capacity for individuals to collaborate in a virtual place that existed purely to facilitate their interaction (Engelbart & English, 1968). Subsequently, Sutherland’s development of the Head Mounted Display presented authenticity to the virtual space by enabling users to experience it by the visual cortex (Sutherland, 1968). Virtual reality is arguably said to have begun with Sutherland’s 1964 head mounted display, as it refers to an environment that consists of computer generated
context that is typically characterized by being three dimensional and inclusive of three dimensional entities and agents (Sherman, 2003). The goal in virtual reality research has been to design and identify the correlates to experiences, whether real or fantastic, that will be perceived by the user as being “real”. Efforts to extend the virtual collaboration space have been explored through the technological advances since the inception of VR to include HMDs, audio devices, tracking devices, and haptic devices (Sherman, 2003). These developments attempt to synthesize the physical world, objects, and entities with imagined world, objects and entities.

2.1.2 Motion Tracking in Virtual Environments

Tracking has been identified as a key concern for many simulated experiences, from small augmented reality to fully immersive simulations. Tracking the orientation of the user and their position has been attempted in many ways including optical sensors, GPD, gyroscopes, RDIF, solid state compasses and wireless sensors. This type of tracking is intuitively understood to increase the user’s sense of presence, the ability of the user to suspend disbelief, and their general understanding of their position or orientation of other objects or agents in the environment (Barandiaran, Paloc, & Graña, 2010; Biocca & Harms, 2002). The importance of accurate representation of a body in space is particularly true of learning simulations in which orientation and location are relevant to the learning objectives, such as physics (Lindgren, 2012).

Over the last several years the technology for tracking motion of an individual immersed in a virtual, mixed, augmented environment has progressed to the point of enabling inexpensive, markerless IR (infrared) tracking with precision to multiple joints.
and appendages. The Microsoft Kinect is one of many consumer products capable of tracking and reporting an individual’s movements on a horizontal and vertical plane. These movements are then used to accurately guide the movement of the virtual camera in the environment. Other consumer ready products include the Leap Motion, which tracks hand and finger movements and gestures that are then used to interact with objects within the virtual space.

2.2 Importance of Fidelity

Research has been conducted for years attempting to quantify the return on investment in areas of functional fidelity and physical fidelity (Martin, 1981; Lapkin & Levvit-Jones, 2011). The United States Department of Defense defines fidelity as the identification of key parameters for a system and the degree to which the aggregate of those parameters match a baseline system. They identify the components of fidelity as functional, physical, psychological, tactile, visual, and wallpaper. For the virtual learning environments investigated here, the elements of fidelity focused on are functional, physical, and psychological.

Some of the methods used to distinguish this relationship include cost-utility analyses that compare the learning outcomes gained from simulators of different levels of fidelity (Lapkin & Levvit-Jones, 2011). In the terms of training, increases in fidelity are not always as effective as expected; rather, the usefulness of increases in fidelity varies depending on the learner, learner’s background, skill level (novice to expert), and learning objectives (Alessi, 1988; Noble, 2002). Research has demonstrated that the
physical, functional, or psychological fidelity interact to contribute to overall authenticity of a simulated events, agents, and environments (Von der Putten, Kraemer, Gratch, & Kang, 2010).

Many practitioners seek to create a trifecta of fidelity in simulations, seeking enhanced physical, functional, and psychological fidelity. While each of these areas has been found to enhance a user’s sense of presence within virtual environments with certain objectives (Gillett et al., 2008; Patel et al., 2006; Thornson, Goldiez, & Le, 2009), the cost for some high-fidelity simulators is higher than value of the benefits (US Department of the Navy, 2010). Further, as researches pointed out in 1998, “It is not enough to concentrate on the fidelity of the renderings and the accuracy of the simulated behaviors. The environment should help trainees develop an understanding of the task and should provide guidance and assistance as needed” (Johnson et al., 1998, p. 523). In other words, while fidelity may be important for enhancing different aspects of a simulation or virtual environment, a high-fidelity system is not a substitute for effective educational strategies. There is not enough information to determine the importance the existence and realism of character and personality traits in virtual humans, but there are growing concerns about the unethical or harmful applications of the emerging technologies and virtual experiences spawned by technological determinism.

2.3 Trifurcation of Presence: Physical, Social and Co-presence

Scholars have long understood that a distinction exists between perception of the natural world and perception of the mediated world (M. Lombard & Ditton, 2000) that
create different outcomes. Overlooking these distinctions confounds explanations and analysis of the subjective experiences and outcomes of experiences mediated by virtual/mixed/augmented reality. Researchers distinguish between physical presence, co-presence and social presence by describing physical presence as a sense of “being there,” co-presence as “being there in a shared space with another person” (ISPR, 2000; Slater, Howell, Steed, Pertaub, & Garau, 2000; Steuer, 1992) and social presence as the experience of being together with another individual in a technology mediated experiencing without acknowledging or noticing the technology that is connecting the individuals (Biocca & Harms, 2002; Biocca et al., 2003; Wagner et al., 2009). The act of suspending the conscious awareness of the role of the technology mediating the experience, or suspension of disbelief is a common thread throughout research on VR and specifically presence research. Much of the research has discussed physical presence, social presence, and co-presence as if they are intertwined (Bailenson, Beall, Loomis, Blascovich, & Turk, 2004a; Brockmyer et al., 2009; Hayes et al., 2013; Ijsselsteijn, De Ridder, Freeman, & Avons, 2000; Mennecke, Triplett, Hassall, Conde, & Heer, 2011). This quality of inextricability of the variables comprising presence renders interesting challenges to researchers looking to distill possible interactions and identify directional correlation and even causality among the apparently symbiotic relationship between the experiences. However, if the experience of sharing an experience is the common link to social presence, then that may be the way to extricate these variables from one another for a more thorough examination.
2.3.1 Physical Presence

Physical presence is most similar to the initial construct of telepresence (Schloerb, 1995). Physical presence, co-presence and social presence refer to the degree and quality of communication that occurs in the experience (Biocca et al., 2003). Early researchers outlined two inclusive subdivisions of factors of presence, exogenous or endogenous; exogenous factors are created by the generation of the virtual environment, while endogenous factors are subjective and occur within the user (Defense, 2010; Slater & Usoh, 1993). This distinction preceded a shift in research concerning presence that allowed some research to continue focusing on hardware, fidelity, and display devices, while others began to focus on the analysis of experiences in terms of the affect and cognition of the user (ISPR, 2000; Parsons, Cosand, Courtney, Iyer, & Rizzo, 2009).

This was foreshadowed by Steuer in the early writing on presence:

In other words, “presence” refers to the natural perception of an environment, and “telepresence” refers to the mediated perception of an environment. This environment can be either a temporally or spatially distant “real” environment (for instance, a distant space viewed through a video camera), or an animated but non-existent virtual world synthesized by a computer (for instance, the animated “world” created in a video game).

Research surrounding the user experience and learning outcomes of individuals in VR, MR, or AR demands an interdisciplinary approach (Hughes, Stapleton, & O’Connor, 2007; Lindgren, 2012; Mahon et al., 2010). Among the prominent disciplines that have contributed to the research in presence are Computer Engineering, Computer Science, Robotics, Psychology, Education, Communication, Biology, Physiology, Psychophysics,
Medicine, Theater and various intersections and derivatives of these disciplines with others (Bailenson, Aharoni, Beall, Guadagno, Dimov, Blascovich, 2004b; Hughes et al., 2007; Patel et al., 2006; Sheridan, 1994; Slater, Spanlang, & Corominas, 2010). While technological advances increased the experience of presence by using visual stimuli to induce feelings as if one were in another place, reducing the burden on the primary user to suspend disbelief and more pressure on the designer to construct the user experience (Slater & Usoh, 1993; Slater & Wilbur, 1997).

This evolution has expanded the study of presence beyond traditional hardware, software, and user experience, as the variability stemming from idiosyncratic elements of user perspective revealed a need for multimodal research methods to deepen and enrich understanding of the impacts of presence (Biocca et al., 2003; Sheridan, 1994; Thornson et al., 2009). The perspectives of these new scholars studying virtual environments and presence led to a clearer distinction delineating presence into areas of physical presence, co-presence, social presence, engagement, social realism, and psychological immersion (Brockmyer et al., 2009; ISPR, 2000; McMahan, 2003; Patel et al., 2006). The variations that exist between these disciplines add complexity to the findings.

2.3.2 Co-Presence

While physical presence encompasses the conscious and physical aspects of the experience of “being there,” co-presence refers to the experience of perceived proximity. Ironically, the concept of co-presence predates presence. Goffman classified human face-to-face interaction and the social norms of the time when one was in the “presence” of another individual (Goffman, 1964). Goffman’s concept of co-presence started with a
focus on face-to-face interactions, but the concept was then generalized to virtual places, to include the sense of being and acting with others in a virtual place (Slater, Sadagic, Usoh, & Schroeder, 2000). The International Society for Presence Research defines co-presence as an experience in which “part or all of a person’s perception fails to accurately acknowledge the role of technology in her/his perception that the person or people with whom s/he is engaged in two way communication is/are in the same physical location and environment when in fact they are in a different physical location.”

Zhao (2003) created a taxonomy that elucidated the concept of presence further with the distinct categories of Corporeal Presence (face to face), Corporeal Telepresence (face to device), Virtual Telepresence (physical simulation with communicative robots), and Virtual Co-presence (digital simulation with communicative agents). While this taxonomy is useful in describing co-presence and the possible experiences, the dichotomous nature of it cloaks areas that are less clearly defined. Specifically, human in the loop simulation falls into a gap, not being included in the taxonomy. To be clear, Zhao is referring to computer agents as artificial characters within the virtual environments, which renders Virtual Co-presence inaccurate because it avoids explaining the human involved. Similarly, Corporeal Telepresence, or face to device, excludes the role of the technology.

2.3.3 Social presence

Social presence, one of the newer subsets of presence, is not as clearly defined as telepresence and co-presence. But paradoxically, this novel construct is also an old concept from the fields of psychology, anthropology, and sociology. Use of the term ‘social presence’ actually precedes use of the term “telepresence” in the literature (Minsky, 1980; Short, Williams, & Christie, 1976). Social presence has largely been
discussed in terms of its impact on presence, conceivably increasing a primary user’s sense of presence, as it enhances awareness (Short et al., 1976).

The ambiguity of the concept of social presence leaves many researchers to use the terms physical presence, co-presence, and social presence interchangeably and theorists operationalizing social presence with definitions that sometimes mirrored the definitions of physical presence and co-presence. Other researchers write extensively about social presence without ever operationally defining the term.

Some clear distinctions have been made between social presence from physical presence and co-presence with explanations, such as: “Social presence refers to the extent to which the user experiences other beings (living or synthetic) in the virtual world, which beings to appear to react to the participant” (Thornson et al., 2009). Biocca, Harms, and Burgoon (2003) connected virtual experiences to Social Interactionism (Steuer, 1992), in which individuals are dependent upon social interaction in order to construct their own identity. This connection continues to tie education with virtual experiences, as Vygotsky and other theorists have drawn attention to the role of the context in a social interaction that leads to learning (Vygotsky, 1978). The explanations of social presence seem to converge around the shared experience that the technology provides to the individuals. For the purposes of this research the multiple definitions of social presence have been distilled and synthesized to define social presence as the sense of being there with some perceived entity(s) with whom we are sharing an experience. The developers of the learning environments invest in these tools in order to optimize the capacity for collaborative learning.
Inquiries have revealed the fully complex nature of presence and the importance of the phenomena throughout virtual reality, virtual experiences, and other computer-mediated experiences spawned an explosion of research in the areas of engagement, immersion, social presence, co-presence, and social realism (Edirisingha, Nie, Pluciennik, & Young, 2009; Gunawardena & Zittle, 1997; Kim & Biocca, 1997; Yee & Bailenson, 2007). The constructs of social presence and co-presence have been examined and evolved through the lenses of VR/AR/MR environment generation, interface design, communication, education and training and psychology.

2.3.3.1 Interpersonal Communication Research and VR

The complexity and ambiguity of the term, “social presence” is heightened by the fact that the focus of many researchers on presence integrates the factors of social presence without even an attempt to detangle social presence from physical presence and co-presence. Much of the initial discourse on social presence stemmed from interdisciplinary research between technology interface research and human communication research (Frank Biocca et al., 2003) that was published in the forerunning industry journal, Presence. The existing literature around the levels of social presence as experienced by co-located individuals contrast with the research of social presence in computer mediated interactions to reveal social presence as a historical explanation of the ways in which individuals interacted. The literature is interdisciplinary and spans social psychology (Bailenson, Blascovich, Loomis, & Beall, 2003), physiology (Slater, Brogni, & Steed, 2003), and communication. This extension of the domains also adds the concepts of “social presence” as used in the field of education.
The International Society for Presence Research (ISPR) has defined social presence as an experience that occurs when “part or all of a person’s perception fails to accurately acknowledge the role of technology that makes it appear that s/he is communicating with one or more other people or entities” (2000). This is characterized by an individual’s perception that disregards the technology involved in communication with another person or people. This phenomena extends further when the other “person or people” being represented are actually artificial, rendering the “interaction”. Symbolic Interaction Theory, which originated in the fields of communication and psychology elucidate the study of social presence by clarifying that humans seek to make meaning, through shared symbols and interpretation of the symbols they make (Blumer & Morrinone, 2004).

Thornson and Goldiez expanded on the existing notions of social presence with the understanding that social presence relates to an individual’s “representation in the social world (2009)”. Biocca et al. further delineate this construct of social presence, saying that “two users are aware of each other in a virtual space and that mutual awareness is the essence of social presence.” These definitions clearly distinguish social presence with another individual from social presence of oneself juxtaposed with a synthetic human. The theory of Embodied Social Presence (ESP) expounds on this by focusing on an avatar as the “nexus of communication,” (Mennecke et al., 2011, p. 414) and the Virtual Environment (VE) as a “3D space with affordances for communication activities”. These researchers relate the level of engagement derived from the intersection of the VE and embodied social interaction to flow theory (Mennecke et al., 2011).
2.3.3.2 Embodiment

Many studies have identified the real connection that individuals experience with both embodied and disembodied selves in virtual environments (Groom, Bailenson, & Nass, 2009; Kilteni K, 2012; Mennecke et al., 2011). This is consistent with the assertions that the advances in technology will continue to increase levels of fidelity and presence, in which their embodiment in environments will be a significant consideration (Blascovich & Bailenson, 2011; Zhao, 2003). The nuances of the human experience are being slowly implemented in the virtual environments in attempts to increase the depth of the user experiences, immediacy, realism, and conceivably social presence (Janssen, Bailenson, Ijsselsteijn, Westernik, 2010). Newer studies that use the emerging technology, such as the Long Arm Study, have identified a connection that individuals experience with both embodied and disembodied selves in virtual environments (Kilteni K, 2012).

As the experiences become more robust, it is becoming more difficult to isolate the elements of presence from one another (Janssen, et al., 2010). Research projects the future of virtual environments by explaining that, “with agents becoming visually and conversationally realistic, the next frontier of behavioral realism is the interaction between virtual agents” (Nye & Silverman, 2013, p. 110). Discussion of embodiment is being intentionally excluded from this study, as it may confound the impact of the social presence.
While the impact of embodiment has a definite impact on social presence and physical presence, the focus on embodiment is excluded from this dissertation as it convolutes the distinction that is being made between physical presence and social presence. While many of the constructs may be applied to various levels of embodiment, the primary focus of this dissertation is one in which the user is not embodied by an avatar, but is instead acting as himself or herself in the environment.

2.3.3.3 Distance Education Literature

There is a parallel discourse on social presence in the field of distance education. Researchers in this field discuss social presence as, “a measure of the feeling of community that a learner experiences in an online environment” (Tu and McIssac, 2002). This is consistent with the literature in the Computer and Communication fields. This literature begins to address the areas of social context, online communication, and interactivity. One example of this variation of terms across disciplines can be seen in the fact that, in distance education discourse, the concept of “being there” is not referred to as “presence”, but is replaced with the idea of Cognitive Absorption. This construct encompasses the equivalent ideas of temporal dissociation, focused immersion, heightened enjoyment, control, and curiosity (Leong, 2011). Another online learning researcher asserts that, “social presence is a quality of people in online environments, conveyed through their use of language, media, and communications tools. Participants in technology-mediated environments cultivate social presence to achieve meaningful interactions, establish and maintain relations, and create productive social systems in these environments” (Kehrwald, 2008).
Social presence has been useful in predicting satisfaction in distance learning (Leong, 2011) but was found to be only a factor to student satisfaction mediated by cognitive absorption, or social presence, and relies on factors such as student’s interests. Researchers in education have called for more explicit measurement approaches to understanding the social connectedness that increases student retention rates and ultimate success in online programs (Lombard & Ditton, 2000; Slagter van Tryon & Bishop, 2012). Recently, social presence has been found to be relevant to learning outcomes (Hostetter & Busch, 2013), but the difference in operational definition of social presence is different in the field of distance education from the area of virtual reality research limits the generalizability of these findings to VLEs.

2.3.3.4 Converging to Shared Experience

The synthesis of the explanations of social presence converges to a common thread in the discussion that crosses these disciplines. These all explicitly or implicitly revolve around the social presence being a description of the perception of a shared experience with another that the technology provides to the individuals. Much of the research has discussed physical presence, social presence, and co-presence as if they are inextricably intertwined. This quality of enmeshment of the variables poses interesting challenges to researchers looking to distill possible interactions and even identify directional correlation and even causality among the apparently symbiotic relationship between the experiences. However, if the experience of sharing an experience is the common link to social presence, then that may be the way to extricate these variables from one another for more thorough examination.
2.3.4 Factors of Social Presence

The existing literature expresses the concept of social presence and measures of the same in many ways that can be distilled down to the basic fundamentals of human psychology, communication and connection. These fundamentals include Affect (feelings and emotions), Behavior (actions), and Cognition (our internal thought processes). This classification diverges from exogenic and endogenic, as the elements in the psychological model are all referring to the experience and perception of that experience that the end user perceives. Once the factors of social presence have been filtered into these categories, the concept of social presence is easier to visualize through a structural model in which the elements interact with one another to build a deeper experience of social presence.

The literature has collectively defined several factors as either contributing to, constituting, increasing, detracting, or predicting presence (Gunawardena & Zittle, 1997; Patel et al., 2006; Thornson et al., 2009; Witmer & Singer, 1998). Table 1 includes factors that have been identified in the literature as contributing to the experience of social presence. These factors are separated in terms of being exogenous and endogenous, a distinction formerly applied to presence by early researchers of this concept (Jin, 2010; Slater & Usoh, 1993).
Table 1 Endogenous and Exogenous Factors of Social Presence

<table>
<thead>
<tr>
<th>Endogenous Factors</th>
<th>Exogenous Factors</th>
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<tbody>
<tr>
<td>Cognitive Involvement</td>
<td>Social Realism</td>
</tr>
<tr>
<td>Novelty</td>
<td>Novelty</td>
</tr>
<tr>
<td>Self-disclosure</td>
<td>Similarity</td>
</tr>
<tr>
<td>Separation anxiety/disorientation</td>
<td>Meaningfulness of experience</td>
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<tr>
<td>Suspension of disbelief</td>
<td>Valence</td>
</tr>
<tr>
<td>Social Action/Social Actor</td>
<td>Manipulation</td>
</tr>
<tr>
<td>Emotional engagement</td>
<td>Active Social interaction</td>
</tr>
<tr>
<td>Flow</td>
<td>Passive Social interaction</td>
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</table>

2.3.4.1 Self Disclosure

Self-disclosure is operationally defined as an individual speaker sharing information about himself or herself that the audience (students) would not already know (Wood, 2009). Additionally, self-disclosure is a behavior that indicates intimacy and trust (Zimmer, Arsal, Al-Marzouq, & Grover, 2010).

2.3.4.2 Social Action/Social Actor

Responding to a virtual agent as if they are a social actor and not just a computer-generated object is considered a demonstration of social presence (Lombard et al, 2009). This can also be seen “when an observer treats a character in a medium as a social actor regardless of whether that actor can respond or is controlled by a human actor (e.g., watching and talking back to a TV anchor)” (Mennecke et al., 2011, p. 414).

Slater, Usoh, and Steed (1994) explain the phenomenon of virtual actors responding to subjects as an indicator of presence. This aligns with observations that participant responses to TeachLivE avatars may indicate levels of engagement. Their discussion was
driven by Heeter’s (1992) assertion that actors spontaneously reacting to the subject increases presence. Their discussion of subjective factors further supports assumptions that an environment in which one’s own body interacts with a blended physical and virtual environment, yields higher levels of presence as opposed to being embodied by an avatar.

2.3.4.3 Social Realism

Social realism is referring to the sense that the behaviors of the agents are authentic and the interactions seem realistic. This is similar to the relationship between physical fidelity and physical presence, wherein physical fidelity is a factor that contributes to physical presence. Similarly, social realism is a factor that contributes to social presence. Research projects the future of virtual environments by explaining that, “with agents becoming visually and conversationally realistic, the next frontier of behavioral realism is the interaction between virtual agents” (Nye & Silverman, 2013, p. 110). This research links the levels of realism created by repetitious behaviors of virtual agents in a simulation and the learning that occurs in those environments. Nye and Silverman assert that “more behaviors do not equal more realism. Reliance on static action sets inherently reduces the realism” (111). They have taken this understanding of the impact of realism to develop a solution to this problem with artificial intelligence that learns socially.

Research has demonstrated instances in which realism or fidelity of a virtual human’s character and behavior has had demonstrated implications on the social presence experienced by individuals in the environment (Bailenson, Blascovich, Beall, & Loomis,
2001; Von der Putten et al., 2010). Scholars note that the Ethopoeia phenomena (Nass & Moon, 2000) reveal that situations or social cues may trigger social action automatically. Similarly, Transformed Social Interaction (TSI) and the Proteus effect are additional theoretical frameworks through which researchers explore the reciprocal relationship between computer-mediated interaction and on social behavior (Bailenson et al., 2004a; Yee & Bailenson, 2007). These automatic reactions, based on random distributions generated by algorithms within systems, do not accurately or adequately represent humans, because human behavior is derived from many invisible factors that are not included in existing models of human behavior (Boy, 2011; Patel et al., 2006).

For the purposes of this study, social realism will be measured by subjective measure and by behavioral measure. The behavioral measure for social realism will be automatic social responses. These include lack of willingness to walk away from students when they are talking or saying goodbye to virtual students.

2.3.4.4 Cognitive Involvement

Involvement is said to be an essential component to presence, and it is critical to social presence (Thornson, Goldiez, Le, 2004; Witmer and Singer, 1998). “Involvement is a psychological state experienced as a consequence of focusing one’s energy and attention on a coherent set of stimuli or meaningfully related activities and events. Involvement depends on the degree of significance or meaning that the individual attaches to the stimuli, activities, or events” (Witmer & Singer, 1998, p. 227). Cognitive involvement and Flow are similar constructs that deal with being absorbed in an experience; however, cognitive involvement can be either active or passive. This is
highly related to engagement as it is “characterized by a feeling of energized focus and full involvement in the activity” (Thornson, Goldiez, Le, 2004, p. 67). “We define passive cognitive involvement as a cognitive state in which the person is fully engaged in what s/he is doing, characterized by a feeling of energized focus and full involvement in the activity” (Thornson, Goldiez, Le, 2004, p. 67).

2.3.4.5 Emotional Engagement

Engagement is another widely used and ambiguous term, with many denotative meanings, but the connotations of emotional engagement are essentially consistent. Engagement is generally seen in industry and in psychology as being cognitive, or focused and attentive, emotionally involved, and social, or relating to other people (Cunningham, Hall, & Young, 2006). For the purposes of this research, engagement refers to the state of an individual being affectively, behaviorally, and cognitively involved with an experience. This manifests in attention, interest, physical presence, physical activity, social presence, and motivation.

2.3.4.6 Novelty Effect

It is difficult to extricate the impact of the novelty of experiencing virtual environments from the variables of motivation and engagement. This is particularly true of the subjective perspective of users who may experience fun but not be able to identify or pinpoint the stimulus that generates the effect of pleasure (Gibson, 2008; Slater et al., 2006; Taylor & Binder, 1973). “Technological novelty is the quality of perceiving digital platforms as unfamiliar interesting, and unlike those presently used or understood” (Tokunaga, 2013, p. 3). The effect of novelty experienced can be positive or negative on
learning, transfer or sense of engagement (Jacko & Sears, 2008; Taylor & Binder, 1973; Tokunaga, 2013). This must be taken into consideration when evaluating both the user experience and the effectiveness of a virtual environment or experience.

2.3.4.7 Meaningfulness of Experience

Meaningfulness, in relation to virtual objects and environments, refers to realistic perceptual organization (Slattery, 2008). “Meaningfulness pertains to user motivation, task saliency, and previous experience. A more meaningful situation will increase user presence” (Nam & Johnson, 2006, p. 22). While meaningfulness of experience was used in the early discourse about presence, it is appropriate to apply this factor to social presence. In fact, meaningfulness of experience was discussed prior to discussions of “social presence” in virtual experiences. The idea of social presence could easily be substituted for presence in this early analysis, “Presence should increase as the situation presented becomes more meaningful to the person. Meaningfulness is often related to many other factors, such as motivation to learn or perform, task saliency, and previous experience” (Witmer & Singer, 1998, p. 230). This is best illustrated when looking at meaningfulness as immediacy of control, authenticity of the responses and consequences of one’s actions (McGreevy, 1992; Witmer & Singer, 1998).

2.3.4.8 Suspension of Disbelief

Understanding the nature of the experiences of individuals with physical presence, co-presence, and social presence is predicated on understanding the subjective nature of these phenomena. Suspension of disbelief, immersive tendency, introversion, and empathy are subjective elements that relate to this research into learning within a
virtual environment (Thornson et al., 2009). Originating from perceptions around media such as theater, suspension of disbelief is the phenomenon in which a participant in a virtual/ synthetic/ augmented environment is able to overlook and even forget the fact that the environment is not natural, but constructed and contrived, in order to enhance engagement, presence, and belief of the experience being provided/created (Boellstorff, 2011; Dede, 2009; Jeffries, 2008; Kantor, Waddington, & Osgood, 2000; LeRoy Heinrichs, Youngblood, Harter, & Dev, 2008; Maynes & et al., 1996; Park, Calvert, Brantingham, & Brantingham, 2008; Serby, 2011; Steuer, 1992).

The original concept of suspension of disbelief was actually referred to as willing suspension of disbelief, in which the implication of a conscious action on the part of the participant is central (Steuer, 1992). This idea, originating with the poet Samuel Coleridge in the early 1900s, is being challenged by the technology of the day, in which one may willingly suspend disbelief but the technology may also have the power to envelope the user yielding less power than an individual who chooses to pick up a book (Holland, 2008).

Whether it is active or passive suspension of disbelief, the suspension of disbelief is a central element to measuring presence and social presence. There is consistent discussion of suspension of disbelief as a contributing factor or sub-construct through description, analysis, and measurement of both presence and social presence (Slater & Wilbur, 1997; Slattery, 2008; Steuer, 1992). These areas of presence have been defined as creating an experience in which the technology mediating the experience “fades” or goes unnoticed or unacknowledged (ISPR, 2000; Mennecke et al., 2011).
2.3.4.9 Active or Passive Social Presence

Another key consideration about social presence throughout the literature is the contrast between active and passive social presence (Lombard & Ditton, 2000). As Slater noted in reference to presence, “it is argued that reality is formed through action, rather than through mental filters” (Slater, 2004). Similarly, researchers distinguish social presence to include verbal or physical action, whereas they refer to perceiving the other as passive social presence (Lombard, Weinstein, & Ditton, 2011). Lombard et al. (2011) aptly describe Active Social Presence in terms of how often a social actor engaging with an environment makes sounds out-loud, such as laughing or speaking or smiling in response to something that the other social actor does. Inversely, they describe passive social presence as observing the nonverbal behaviors of the other social actor, such as facial expression and tone.

2.3.4.10 Absence as a Measure of Social Presence

Another effective measure of social presence was derived by Schultze in which presence is contrasted with “absence” as an occurrence in which “an individual retreats from the shared world of the here and now into a private, internal and imagined world of the mind” (Schultze & Orlikowski, 2010). The distinction between presence and absence, drawn by Waterworth and Waterworth (2008) refers to the attention or inattention to internal or external stimulus. Absence, in this case refers to the lack of presence, and is, indeed the inverse of presence, as when one becomes more present in the physical world the loss is to presence in the virtual world, and vice versa. These observations reveal “absence” as a potential inverse measure of social presence.
Table 2 Factors that contribute to Social Presence

<table>
<thead>
<tr>
<th>Immersive Tendency</th>
<th>Ability to Construct Mental Models</th>
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<tr>
<td>Openness to Experience</td>
<td>Empathy</td>
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<td>Introversion</td>
<td>Intention</td>
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<td>Age</td>
<td>Technical Experience</td>
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<td>Prior Experience</td>
<td>Selective Attention</td>
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2.3.5 Confounds to Understanding Social Presence

The first confound to understanding social presence is the breadth of terms and meanings and level of impact ascribed to the phenomena. This ambiguity befuddles conversations about education, VR, and MR as people struggle to gain some continuity of the concept. Aside from the ambiguity of the term and the conflicting denotations and connotations of presence, there are subjective and contextual confounds to identifying and understanding presence. Personal attributes that influence social presence that are identified in the body of literature include immersive tendency (Witmer and Singer, 1997), openness to experience, introversion (Thornson et al. 2007), age and prior experience (Youngblut & Huie, 2003), and ability to construct mental models (Lee, 2004; Schultze & Orlikowski, 2010; Thornson et al., 2009).

This research synthesizes the factors that the existing literature has identified as either constituting presence or contributing to presence. This synthesis of researchers’ assertions about social presence can add to current understanding of social presence and approaches to identify and measure the phenomenon.
The subjectivity of presence instruments is a common contention throughout the field of presence research (Biocca, Harms, Burgoon, 2003, Bailenson et al. 2004; Slater, 2004). In “How Colorful Was Your Day,” Mel Slater stated it most directly, “researchers interested in studying the concept called presence might find a way to abandon the easy but ultimately useless employment of questionnaires, and search for a better way to capture this elusive concept…There are many responses to a VE experience— gross behavioral, eye movements, measurable physiological responses, what people say in interviews, how people respond to questionnaires. Why elevate just one of these to be the preeminent position that it now has? Is it only because it is the easiest approach to take.” (2004)

2.4 Measuring Physical Presence, Co-presence, and Social Presence

Physical presence and social presence are frequently used to quantify the value and the efficacy of virtual environments and experiences (Slater et al., 2010). Emerging technologies have made varying degrees of virtual experiences attainable by consumers. The exponential growth of computing power, increases in bandwidth, increases in high resolution displays, and overall democratization of personal computing machinery has increased the potential usage of virtual environments for training, education, and recreation (Ambient Insight Research, 2010; Bolas et al., 2013; Mollick, 2006). This evolution has spanned to include collaborative workgroups, virtual schoolrooms, and persistent virtual worlds in which all things from the physical world may theoretically exist. It is now the case that an individual can spend a majority of his or her time
immersed in some variation of a virtual, mixed, or augmented environment that is either experienced on a computer screen, though a head mounted display, or even on a mobile device (Krum, Suma, & Bolas, 2012). Pervasive implementation of virtual objects, virtual environments, and virtual worlds has increased the need to measure their effectiveness.

Over the past twenty-five years of presence research there have been multiple approaches to measuring the experience from qualitative to quantitative subjective measures, physiological measures, and qualitative analysis. There are several frequently cited instruments for the subjective measure of presence, such as the Hendrix and Barfield (1999) questionnaire, Biocca (1997) questionnaire, SUS (Slater, Usoh, Steed), Witmer and Singer (1998) ITC and Presence questionnaires, Mania’s questionnaire and Tromps. These questionnaires all vary slightly by the type of virtual experience being measured and the approach to operationalizing the experience of presence.

2.4.1 Measuring Presence

The measurement of presence regards the level at which a synthetic, virtual, augmented, mixed reality, or otherwise computer mediated experience elicits affect, behavior, and cognitive processes that are elicited by stimuli in the real world. Presence research over the last twenty years encompasses qualitative and quantitative approaches, including questionnaire research, self-reflection, physiological measures, and empirical findings (Patel et al., 2006; Slater & Usoh, 1993). This evolution of presence research has been accompanied by a heightened awareness to the nuances of defining and measuring presence as well as the implications of presence on embodiment and
engagement. This discourse is intended to inform current VR researchers of the complex considerations for thorough analysis and understanding of presence in virtual environments. Because the literature reveals that communication is critical to pedagogy the review includes an analysis of existing approaches to teaching pedagogy in virtual, mixed reality, and augmented reality environments. The literature also reveals that the existing approaches to teaching interpersonal skills highlight constructs of presence, co-presence, and fidelity as indicators of the quality of a computer mediated environment.

2.4.2 Challenges to Subjective Measures of Presence

The questionnaire approach, while revealing, has been deemed incomplete when it comes to distinguishing the chief factors that contribute to the sense of presence. These measures also fail to provide enough information to form generalizable predictions about the experience of presence (Hayes et al., 2013). Also, this can be further confounded by an individual’s inability to dissect his or her own perceptions. For example, someone who is highly visual might rate presence high based entirely on the perception of visual fidelity being high, for purely aesthetic reasons, rather than because they actually experienced a sense of presence. “The growing group of researchers interested in studying the concept called presence might find a way to abandon the easy but ultimately useless employment of questionnaires, and search for a better way to capture this elusive concept” (Slater, 2004, p. 492).

Behavioral measures, while more objective than the self-report, also suffer the consequences of being subjective. A great deal of research and training go into preparing
someone to be a coder for a construct as ephemeral as social presence. Further, once the training is complete, inner rater reliability becomes a chief concern. This process is costly and time consuming. For example, University College London Presence Questionnaire offered questions for observed behavioral presence, contrasting the behavior in a physical experience to a virtual experience. The researchers questioned whether “users act as if in a similar real environment.” This practice aligns with the proposed study’s efforts to cross validate subjective measures with objective measures.

2.4.3 Measuring Social Presence

Social presence has been measured through multiple approaches and with varying methodologies. Similar to physical presence, social presence has been measured with subjective measures, behavioral measures, and physiological measures. Throughout the literature a consensus exists that the drawbacks of each of the approaches may be offset by integration or cross-validation with other approaches.

2.4.3.1 Subjective Measures

Lombard and Ditton created a questionnaire (2000) that measures social presence as divided into six constructs: social richness, realism, transportation, immersion, social actor within medium, and medium as social actor. This 103-item questionnaire measured both physical presence and social presence. Nowak and Biocca’s questionnaire (2003) measured physical presence, co-presence, and social presence with 29 items, only six of which measured social presence. The Temple Presence Inventory, the Thie & Van Wijk
questionnaire, and the Schroeder et al. (2001) measure multiple aspects, including social presence, physical presence, telepresence, and co-presence.

The research community shifted to measuring social presence as a construct of its own. In 2004 Jeremy Bailenson and colleagues constructed, tested, and published an instrument for social presence in conjunction with behavioral measures. This 13 item questionnaire included five items on a 7-point scale ranging from negative three (strongly disagree) to positive three (strongly agree). The other items included co-presence and likability.

2.4.3.2 Empirical Measures – Autonomic Responses

The approach of measuring autonomic responses and collecting data have been effective in gaining insight into the physiological experiences that accompany the experience of presence (Meehan, Insko, Whitton, & Brooks, 2002; Meehan, Razzaque, Insko, Whitton, & Brooks, 2005; Slater et al., 2003). Much of this research includes the measures of stress as operationalized by changes in heart rates and skin conductance, by means of Galvanic Skin Response (GSR) (Meehan et al., 2002; Meehan et al., 2005). Heart rate has been used as a physiological measure of presence throughout the literature, and it considered a more reliable measure than the GSR or changes in temperature (Meehan et al., 2002; Meehan et al., 2005; Slater et al., 2006). These criteria are also used to indicate elements of presence, such as engagement, attention, and immersion (Slater et al., 2003).
2.4.4 Triangulating Presence

Early definitions of virtual reality explain it as a “type of experience (in terms of "presence" and "telepresence") rather than as a collection of hardware)” that should be measured in terms of interactivity and vividness (Steuer, 1992, 1). Early exploration of the experience of telepresence called upon researchers to draw upon existing knowledge of the subjective nature of consciousness and perception, highlighting the importance of presence, or “being there” (1980, pg. 2) in a location other than that of the physical body though the context, entities, and agents portrayed in a virtual reality environment are perceived as real. This rationale explains how the study of presence is integral to the development and improvement of experiences set in virtual environments.

“Presence is not experienced the same way, with the same intensity or same frequency by everyone. Furthermore, an individual will experience presence differently at different times” (Heeter, 2003, 337). Mel Slater exemplified this in the article, How colorful was your day, in which he demonstrated the capacity that researchers have to a posteriori create constructs and give them meaning that they did not have. The ambiguity or subjectivity inherent in each of these measures is driving a shift in the area of presence research that suggests that meaningful research about presence will include multiple approaches (Bailenson et al., 2004b; Heeter, 2003; Slater, 2004).

University College London research on behavior and presence was quantified by physiological measures of stress responses, such as heart rate and blood pressure. Additionally, it integrated behavioral measures with the physiological metrics. Slater and Steed’s (2000a) virtual presence counter, Breaks in Presence (BIP), requires a participant to verbally report when he switches from experiencing the virtual world to experiencing
the physical world. This subjective measure indicated a sense of physical presence, but was more verifiable than a questionnaire, particularly because this was also verified with physiological data. This approach of validating findings across methods in a research study, either hard or soft validation has been indicated by the existing body of literature.

A myriad of studies that focus on only one approach to measuring presence have concluded that multiple approaches are necessary to fully understand the construct (Bailenson et al., 2004b; Lombard et al., 2011; Slater, 1999, 2004; Thornson et al., 2009; Witmer & Singer, 1998). Therefore, research seeking to understand and explain presence will have to triangulate between physiological, behavioral, and self-report data. This includes the derivations of presence as well as the emerging technologies. The expansion of the technology has generated some unanswered questions in the areas of MR and VR. One question is whether mixed reality or Virtual Reality is more effective in eliciting presence and/or social presence and whether these are higher in MR than in VR (embodied or not). The embodied nature of mixed reality might lead some to expect that the experience would be more effective in these areas, but this is not known. Because the measures are incomplete, the answers to these questions are also untouched. "In sum, to understand how large the potential a medium has to change an individual, researchers have typically measured how realistically a user behaves while inside of that medium” (Yee, 2007). Yee’s statement lends itself to support a suggestion that the immersion of oneself into an environment, as is standard with mixed reality, would maintain more of the typical and realistic behavior than that of an experience being embodied by an avatar.
2.5 Distinguishing Virtual, Mixed, and Augmented Reality as Simulation

Augmented reality is part of the classification of “mixed reality” along the Milgram and Kishono 1994 “virtuality continuum,” differentiating Virtual Reality from Augmented Reality (Figure 1). Progressing from left to right, the continuum begins with “Real Environments” toward the right side of the continuum which portrays a completely virtual experience, in which the user experiences only computer generated stimuli and no part of the environment “real”. Progressing through the continuum real objects are more prominent and dependence on Virtuality decreases. Mixed reality is unique in its provisions for a technology that is closely aligned to the real environment, effectively blending the possibility for the user to intuitively link both virtual and “real”.

![Virtuality Continuum](image)

Figure 1 Virtuality Continuum

Augmented reality works by superimposing an overlay of virtual data (objects, information, scene, building etc.) on the real environment, either by projecting onto it or by a visual display that places the virtual objects into the field of vision of the target user. The primary components of AR consist of a scene or object generator, tracking system and display (Silva, Oliveira, Giraldi, 2005). The scene generator renders the virtual object by use of software. The tracking device gives the ability to map and register virtual data.
to the real environment. The display is the medium used to project the rendered virtual data via the tracking device. Each of these components has progressed since its introduction in 1968 by Ivan Sutherland with the most imperative being the tracking device (El-Zayat, 2011).

Many of the studies conducted on Augmented Reality systems measure the user experience but do not quantify the effectiveness and efficacy of the specific tool being evaluated. These measurements of user experience are generally positive, indicating user engagement, enjoyment, and preference over other methods of instruction (Dunleavy, Dede, & Mitchell, 2009; Thomas, William John, & Delieu, 2010). This is a valuable finding, which alludes to engagement, but engagement without demonstrated benefits to learning can be easily questioned. The correlation between user satisfaction and effectiveness are often negligible and should be looked at separately (Frokjaer, Hertzum, & Hornbaek, 2000). In fact, the domains of usability include effectiveness of the tool in addition to the efficiency and user experience. Essentially, while user experience is important, a full evaluation of the technology will contain both a thorough usability study that includes the technologies effects on learning and transfer of knowledge.

Researchers for the corporation, Nokia, looked at evaluation beyond the quantitative metrics. While they used the Singer presence questionnaire, they also used questionnaire and self-report data to determine not only the quantitative performance improvement, but also the more subjective user experience. “Because of this our evaluation metrics for the study were questionnaire and interview based rather than strictly task performance based” (Wither, Tsai, & Azuma, 2011). They go on to explain that the variable of presence is not the same in AR as it is in VR, as the users are present...
in the physical world. Instead, they focused their attention on the interaction between the physical and computer-generated objects/entities:

“When designing our questionnaire we looked at previous work in a number of fields for inspiration. In one sense the questions we are interested in relate to presence, as defined in the VR community. However, presence in this sense does not translate very well to AR since users are always present in the physical world.” They posit that this confound renders the Slater and Steed or Witmer and Singer questionnaires less effective and less relevant. They also note the difficulty in applying unmodified instruments in the highly variable context of augmented reality. This is particularly true when there are numerous kinds of interaction in augmented reality, augmented virtuality, and mixed reality. Instead of just looking at perceptions of the virtual environment, there are also interactions between “real” and virtual objects, and interaction between real objects as mediated by the virtual elements. Wither et al. (2013) found it most effective to develop a very specific instrument for their purposes.

2.6 Learning in VR/AR/MR Simulations

The initial consideration for this area is the viability of this technology as a tool for teaching and learning. Research from the disciplines of social psychology, education, simulation and training as well as much of the literature on training in simulations and Virtual Learning Environments (VLEs) provide insight. To begin with psychology and education, Bandura’s social learning theory can be used to understand much of the phenomena that surround Computer Mediated Learning Environments. Bandura posits
that social interaction and connection are essential to learning. This aligns social presence and social realism that are endeavored by the designers and developers. Research by Bandura and Vygotsky speak to the social aspects of human learning (Vygotsky, 1978). These elements are important in face-to-face communication in the physical world and can also be experienced and observed in the virtual environments. In the new era of social media and widespread technology adoption, this is not only relevant to the masses, but also accessible to increasing numbers of people every day.

One thing that should be noted in comparing virtual Reality, augmented reality, and mixed reality is the embodiment of the individual experiencing the environment. These all deviate from physical presence in the physical world. In Virtual Reality, the physical embodiment is irrelevant, as the entire experience is generated within the technology. In Augmented Reality, some virtual elements are used to augment objects in the physical environment. The augmentation could be people, labels, heads-up displays (HUDs), simulated or invented objects. Mixed reality works to seamlessly integrate virtual objects and physical objects. The lofty goals of integrating physical and virtual objects entails continuous tracking of the physical objects in order to maintain the relation to the virtual objects. The technology orients the view and plots the virtual objects in the real world. This has proven to be a nontrivial task as, depending on the speed of the tasks and behaviors in the experience, latency may diminish or even prohibit the experience.
2.6.1 Effectiveness of VR/AR/ MR in Education and Training

“The point is that we drive an MR experience by generating a world within, on top, beneath, and around the real world and real senses that we live in (Hughes et al., 2007).” This “reverse engineering of social interactions” was alluded to by Bailenson et al in the discussion of the categories of Transformed Social Interaction (TSI) (2004a). Bailenson posited that TSI’s self-representations, sensory capabilities, and contextual situation could all be manipulated to create a desired social interaction (Bailenson et al., 2004; Fox, Bailenson, & Binney, 2009; Patel et al., 2006). Further, these researchers have found that the experience of presence is correlated with greater impact of these experiences and environments.

2.6.2 Learning and Training Theory

Training research has evolved to distinguish types of fidelity that are used to evaluate the validity and the authenticity to simulated objects, scenarios, or systems: functional fidelity, physical fidelity, and behavioral fidelity. There has been a great deal of contention as to when high fidelity simulations are cost effective, as demonstrated in Miller’s Curve and repeated in multiple analyses since that time (Miller, 1953).

2.6.3 After Action Review (AAR) in Simulation

An essential component to learning in simulation is the After Action Review (AAR) of the performance in which the participant reflects on their performance, preferably with the guidance of an expert, to identify successes and opportunities for improvement. After Action Review predates virtual simulation as an approach to improving practice and avoiding negative training (Department of the Army, 1993).
AAR has gained additional functionalities with the advent of virtual simulations. AAR in virtual environments with avatars and agents “enables users to review their H-VH (human – virtual human) interaction, evaluate their actions, and receive feedback on how to improve future real-world, H-H (human-human) interactions (Raij & Lok, 2008). This new approach to simulation with virtual elements or environments allows augmentation of the experiences that can be explored in the after action review. Additional data can be collected and reviewed, such as body language, natural speech, special and temporal functions, as well as system states (Raij & Lok, 2008). All of these elements can be used to enhance a human’s understanding of his/her own behavior allowing the learning to be transferred to the interpersonal interactions.

2.6.4 Importance of Interpersonal Connection for Learning

Recent research has revealed a direct correlation between social connectedness and learning, as well as between social connectedness and retention (Light, 2004). Simpson and Oser’s 2003 analysis of evaluating large Scale Simulation highlights experiment, judgment, analysis, and survey as the effective tools that enhance the typical analysis of cost and cost-effectiveness. They draw on Kirkpatrick’s (1976) prescription for training analysis to include reaction, learning, behavior, and results.

2.6.5 Intersection of Engagement, Involvement, and Psychological Immersion

Dede (2009) refers to immersion in terms of an individual’s subjective experience of virtual objects in which they feel like they are physically and cognitively there, which is facilitated by the user’s willing suspension of disbelief. Dede concludes that the higher the level of immersion provided in the technology, the more the participants will be able
to suspend disbelief. Inherent in this revelation is the question, “to what degree of immersion must a designer strive in order to maximize the immersion and suspension of disbelief”.

Historical understanding of human thought and perception shines light on the experience of immersion. For example, John Dewey (1933),

When one is doing something, one is compelled, if the work is to succeed (unless it is purely routine), to use eyes, ears, and sense of touch as guides to action. Without a constant and alert exercise of the senses, not even plays and games can go on; in any form of work, materials, obstacles, appliances, failures, and successes, must be intently watched. Sense-perception does not occur for its own sake or for purposes of training, but because it is an indispensable factor of success in doing what one is interested in doing (p.42).

Researchers note the intertwined and even symbiotic relationship between the immersion, presence, suspension of disbelief and engagement with an experience (Harteveld, 2011; Murray, 1997; Thornson et al., 2009).

2.7 Experiential Learning in Simulations

Roleplaying has been employed as a type of training simulation throughout history; from military tactics training to business negotiation training or training in medical practice (Bradley, 2006; Smith, 2010). Simulation in virtual environments provides an opportunity for the rehearsal of potentially hazardous activities in a safe and
controlled environment (Alexander, Brunyé, & Weil, 2005). Further, simulation allows students to learn by doing, rather than learning by reading, as is suggested by the term “experiential learning”. This approach facilitates education for the student by demonstration and practice in the way that John Dewey (1933) described as learning by doing. “Because the student and the agent are in the same environment, they can interact with each other in a more natural away, akin to the way human tutors and students interact-through gaze, gestures, and the like” (Johnson et al., 1998, 526).

John Dewey’s focus on experiential learning has been often overlooked in fields that relate to Interpersonal Communication. The irreversible nature of communication demands preparation, particularly in high-stakes situations, in which errors or ineffective communication can have dire consequences. This aligns with the intentional use of simulation training as a preventative measure for high-risk tasks.

2.8 TLE TeachLivETM

TLE TeachLivETM (referred to here simply as TeachLivE) is a virtual environment classroom simulation that is designed to train education professionals how to improve their interpersonal and teaching practice including, but not limited to delivery of content, engaging students, and classroom management (Dieker et al., 2014; Hayes et al., 2013; Hayes et al., 2014). In TeachLivE the teacher is physically located in a physical location where the virtual students and virtual objects of the experience are virtually represented on a large screen display, constituting a mixed reality experience that is biased towards the Augmented Virtuality interval along the Milgram continuum.
The users of the system experience encounters five virtual student avatars sitting in desks or around tables on a large screen display. These students exhibit behaviors that reflect characteristics of research-based student archetypes in order to prepare the users for the real classroom. The experience is delivered over the Internet, using Skype video call as VOIP to accompany a 3D rendered classroom with five student avatars to over 70 teacher practice sites across the world. The simulation with over 12,000 teachers rehearsing their classroom experience affords the user to practice behaviors that are common skills in TeachLivE in a physical classroom. Figures 2 & 3 juxtapose the traditional classroom with the virtual classroom.

Figure 2 Traditional classroom teacher interaction Vs. TeachLivE virtual classroom
While the various sites primarily employ TeachLivE for pedagogical development of pre-service teachers, each site utilizes the resource differently. Some sites have a scaffolded approach, while others are less structured with open sessions for experiential learning (Andreasen & Haciomeroglu, 2011; J. Walker & Dotger, 2012; Whitten et al., 2013). Each of these approaches is in line with the philosophies that drive experiential learning.

Western Michigan University (WMU) researchers have coined an acronym for the skills and instruction techniques acquired during the training in TeachLivE. They refer to SPARC to denote the array of skills they expect teachers to develop (Specific praise delivery, Planned questioning, Anticipatory set to closure, Research Based Strategies, and Connecting to students) (Whitten et al., 2013). These variables are largely socially based, which aligns with measures of social presence, as opposed to physical presence.

Existing research about simulated scenarios in virtual classrooms has demonstrated that the tool is effective (Dieker, Straub, Hughes, Hynes, & Hardin, 2014;
Hayes et al., 2013; Mahon et al., 2010; Whitten et al., 2013). This research will add clarity to the features of the simulated classroom that have the highest impact. What subjective measures miss is the imperceptible, unconscious and subconscious experiences. Subjects often fail to notice and/or fail to be capable of articulating their experience. The reliability of the measure between participants is also questionable with subjective measure.

Within the pilots the TeachLivE reflection system, ReflectLivE, is used to facilitate after action review with participants. The system affords participants to view their performance juxtaposed to the class on one screen. It also enables participants and faculty or supervisors to tag behaviors in the virtual rehearsal for reflection, discussion, and possible improvement or reinforcement, as appropriate.

The pilot studies in the upcoming chapters follow the development of research questions that led to the current study. The first pilot focused on modifying the Witmer and Singer presence questionnaire, qualitative analysis of the user experience, learning outcomes, and transfer of learning for four participants using TeachLivE. The outcomes from that study led to the focus on social presence and reduced focus on learning outcomes. This study was supplemented by concurrent large scale research study into the learning outcomes, transfer of learning, and retention (Straub et al. 2014). The discovery that participants in the TeachLivE environment had higher learning outcomes, transfer, and retention than other training modalities has enabled the current researcher to focus on identifying the elements of the simulation that contribute to those outcomes.
Figure 4 Teacher movement not tracked so view is always front of class

Figure 5 Teacher movement is translated to virtual camera movement
This initial formative pilot study focused on exploring a hypothesized relationship between the user’s experience and the learning outcomes and transfer of training. This included both a case study with four participants and a test of the modified presence questionnaire administered to 24 participants. These studies are reported together in this chapter, given the small size of each of them. In order to test this hypothesized relationship between the user’s experience and the learning outcomes and transfer of training, the researchers integrated learning objectives into scenarios that could be measured through evaluation before and after the training was delivered. A baseline was established by observing the practicing teachers in their actual classrooms, then the teachers were observed in the lab, delivering a lesson to virtual students. Concurrently with the case study research, participants using TeachLivE were asked to participate in a small study of perceptions of presence using the Modified Presence Questionnaire.

3.1 Education Constructs Evaluated

The constructs being evaluated in the study for learning are specific praise, wait time, and higher order questioning. Each of the constructs is operationally defined below.
3.1.1 Specific Praise

The researchers chose pedagogical practice on which to focus the training task based on strategies that education literature identified as important for teacher improvement. These constructs were: a) the use of specific praise vs. general praise, b) wait time, and c) the use of higher order questions. For the purposes of this study, specific praise refers to positive statements about performance that are explicit in identifying the exact behavior, in order to reinforce and increase the occurrence of the targeted behavior (Kalis, Vannest, & Parker, 2007; Hawkins & Heflin, 2010; Feldman, 2003; Reinke, Lewis-Palmer & Martin, 2007). For example, "Good job on showing your work on every question in your homework." It is a combination of a positive statement linked to the behavior being reinforced such as “Excellent work using a strategy to write your paragraph” (Scheeler, Bruno, Grubb, & Seavey, 2009).

3.1.2 Wait Time

For the purposes of this study “wait time” is defined as the elapsed time after a teacher poses a question, and before the students respond or the question is rephrased or repeated (Stahl, 1994; Tincani & Crozier, 2007; Novak, 1963). In this study, two raters in the classroom recorded the amount of time that the teacher waited for response before restating or asking clarifying questions. The raters were subject matter experts in pedagogy, as they were former K12 teachers who were enrolled in a doctoral education program. The threshold for inter rater agreement for this section was two seconds. The average of the raters was used as wait time and any data whose ratings exceeded the threshold was discarded.
3.1.3 Higher Order Questioning

Higher Order Questioning was selected as a strategy to train and measure teacher development in TeachLive, as TeachingWorks, in their report entitled Measures of Effective Teaching, distinguishes higher order questioning as the strategy of a highly effective teacher (Foundation, 2011). For the purposes of this study we defined “higher-level questioning” as questions that allow students to use past experiences, prior knowledge, and previously learned content and relate it to newly learned content in order to create an open ended and well thought out answer (Danielson, 2011; Winne, 1979). The raters were subject matter experts in pedagogy, as they were former K12 teachers who were enrolled in a doctoral education program. Raters were trained in the criteria for recognizing questioning and missed opportunities for higher order questions as defined by the Danielson Framework (Danielson, 2011).

3.2 User Experience Measures

This pilot study integrated interviews and self-report through an after action review (AAR) reporting sheet and a questionnaire. The questionnaire used was created for mixed reality environments and was based on the questions from the Witmer and Singer presence questionnaire (1997).

3.2.1 Qualitative Presence and User Experience: Interviews

In the interview the participants disclosed their experience of presence, suspension of disbelief, and immersion through self-report. The interview questions included learning, suspension of disbelief, presence and immersion:
3.2.2 Qualitative User Experience Measure: Observation

The researchers utilized observation as the qualitative approach to interpret the user experience. Presence can be measured by observing reflexive responses to stimuli, such as a participant reaching to catch a ball or flinching or jumping at a stimulus (Sheridan, 1994). A reflexive response can be physical, but may also be a reflexive social response that can subsequently be used to measure presence (Sheridan, 1994). The social responses might include replying to a question, apologizing, or simply saying goodbye before walking away. While this measure could also be called a measure of the level at which a user has suspended disbelief, this study does not apply it as such a measure. For this research, social reflexive responses were noted by the observer and then the primary user of the VLE was asked for feedback on their internal thought processes when exhibiting those behaviors during the after action review/debriefing.
3.2.3 Quantitative User Experience: Questionnaire

The interview questions for the study were derived from the operational definitions for presence, suspension of disbelief, and immersion. After explaining to participants the meaning of each construct, the researcher then asked them to verbally evaluate the experience according to each of the three. This study utilized interviews and questionnaires that were derived from the Witmer and Singer constructs and their Presence Questionnaire (1998). Because the Witmer and Singer questionnaire is measuring a virtual environment as opposed to an MR, AR or AV environment, some of the items were eliminated and others were modified. Based on the literature and the case study interviews, we anticipated that relationships between suspension of disbelief and the degree to which the students and environment felt real would be revealed by the questionnaire data. Two of the hypotheses that were tested in our research are:

H1: There will be a relationship between suspension of disbelief and the rating of the environment feeling real.

H2: There will be a relationship between suspension of disbelief and the rating of the students feeling real.

3.3 Mixed Methods Approach

This study began with qualitative measures used to explore the user experience and the learning outcomes. The participants were practicing (K12) teachers in a southern state. The methods in the baseline research were to observe the teacher as they taught their students in their professional classroom environment. The frequency of the target
behaviors, i.e., specific praise, higher order questioning, and wait-time were measured by two raters, to mitigate for the subjectivity of the researcher. The teachers had one orientation session and three virtual rehearsals in the environment in which they delivered a brief lesson to the virtual students. This was done for three separate instances over a period, of two weeks, in the TeachLivE™ classroom. After each virtual rehearsal, the teacher was given a chance to reflect and also receive feedback in an After Action Review session of performance. After all three training sessions were completed; the teachers were once again observed in their classroom where their performances in the constructs were recorded. The baseline and final observation scores were then compared.

3.4 Case Study Methodology and Results

The first stage of this formative research was qualitative in nature, utilizing the open-ended user experience interview questions in two case studies that related to the constructs of presence, suspension of disbelief, and immersion. Four practicing middle school teachers were observed in the classroom where a baseline of performance on the education constructs (wait time, higher order questioning, and specific praise) was recorded. The teachers were then immersed in TeachLivE with session objectives of increasing wait time, higher order questioning, and specific praise. These objectives were generated in collaboration with education faculty who identified these objectives by the practices of highly effective teachers. Upon completion of each of three 10-minute sessions, the teachers were given feedback in the form of After Action Review. After the last session, teachers were observed again in their actual classrooms for a post
intervention evaluation of performance. Also, after their first and last experience in the virtual classroom with the simulated students, the teachers in training were asked questions about their perceptions of the virtual classroom environment and about the authenticity of the simulated student avatars.

The responses indicated some initial apprehension with the virtual classroom environment and the student avatars. They also indicated that the students in the virtual classroom were perceived as being exactly like students that they experience in a real classroom. They established emotional relationships with the students such as frustration, empathy, and happiness when they succeeded in getting them engaged.

After the initial case study and interviews informed the process, leading to modifications of the presence questionnaire, a second stage of the formative study occurred. For this phase, the preliminary questionnaire was administered to a convenience sample of 24 participants, evenly divided between 12 pre-service and 12 practicing teachers, each of whom was assigned to teach a ten-minute lesson in TeachLivE based on the material they were already teaching or preparing to teach in their real classrooms. After teaching in TeachLivE they were administered the abbreviated TeachLivE presence questionnaire.

3.5 Findings from Case Study

The findings of the preliminary interviews and case studies support the hypothesis that highly immersive environments impact learning through the facilitation of targeted practice. During the interviews it was noted that authenticity of scenarios aided in
suspension of disbelief and the sense of immersion. Finally, the fostered sense of playfulness in TeachLivE was noted as being effective for reducing anxiety about the experience.

3.5.1 Does the experience of TeachLivE effect learning outcomes?

Teachers expressed what their own perception of their performance was and were met with the reality of how they had actually performed. Each day, the teachers in the case study improved their performance of the targeted behaviors in the virtual classroom environment. The qualitative research revealed learning in the lab, as evidenced by the fact that the teacher participants improved the target behaviors with each iteration of teaching the virtual students. The skills were also transferred to the physical classroom with real students, as the scores of each of the behaviors were considerably higher in the second measure than they were in the baseline measure of the practice in the classroom.

3.5.2 Do people using TeachLivE experience presence?

The interviews, observations and questionnaires revealed that users are experiencing presence in TeachLivE. In interviews, the comments from the teachers in training included:

“I was so nervous.”

“I can’t believe I made Sean cry; I feel so bad.”

“I couldn’t get her to put her cell phone away.”

The observations also exposed the characteristics of presence. Many teachers’ behaviors indicated presence such as walking up to the virtual student’s approximate location in the physical space while speaking to them, as shown in Figure 6.
3.5.3 Are participants suspending disbelief in TeachLivE?

The case studies and observations of teachers indicate that these participants are able to suspend their disbelief in the system. This is demonstrated by their emotional response to the virtual students’ characteristics and behaviors. When asked, participants expressed that they were able to suspend disbelief, while others said they could not. One student indicated that the experience was useful but still “creepy”.

Figure 6 Teacher in front of class

Figure 7 Teacher view leaning down to talk to student
3.5.4 Do students experience immersion in TeachLivE?

Following Dede’s (2009) explanation of immersion as feeling as though one is experiencing a both comprehensive and realistic interaction, the interviews revealed that participants felt immersed. This is evidenced in the comments from teachers about their plans to change their pedagogical practice in order to address the needs of one or more of the virtual students.

Likewise, the questionnaire data demonstrated that a majority of the users of the system felt the students portray “real kids” (see Table 3). To the contrary, participants rated the classroom as moderately to not at all like a real classroom (see Table 4). This was also consistent with the interview responses in which teachers indicated that there were functional limitations to their practice in the system, such as not being able to physically manipulate the desks and the existence of only five students.

3.5.5 Interaction between presence, immersion, and suspension of disbelief

This research is focusing primarily on the endogenous factors occurring within the user, specifically regarding the constructs investigated in the area of user experience, which included sense of immersion, presence, and suspension of disbelief. While the questionnaire data did not reveal any significant interaction, the case study interviews support the hypothesis that there is some kind of interaction between these constructs.
3.6 Pilot One Discussion

The preliminary case study findings created a foundation for the additional, larger scale quantitative research study reported in this chapter that investigates the relationship between learning and the user experience, specifically suspension of disbelief and presence. The long-term research path includes the exploration of the potential impact on presence derived from different interfaces through which the virtual students may manifest themselves.
3.6.1 Qualitative Findings from Interviews

The interviews revealed that people felt a sense of presence in the classroom and with the students and immersion in the collective world of the class and students, but wanted even greater immersion, asking for new features. Teachers indicated they would like to be able to see work samples of the student’s actual progress and to be able to look over their shoulders. Some of the teachers asked for higher physical fidelity, wanting desks in the room to indicate exactly where the kids would be physically located as they navigated the virtual classroom. While these experiences were easy to discuss qualitatively, the questionnaire did not differentiate in the same way.

3.6.2 Questionnaire Findings

The questionnaire data did not prove as informative as we hoped, but it provided a baseline for future qualitative questions and exposed a need for deeper questions. Additional work needs to be done to validate the questionnaire to ensure that the items are appropriately addressing the intended constructs. The questionnaire does not frame the questions in relationship to anything with which the participants may relate. The scale should be switched from a Likert to a semantic differential; in order to give the participants shared reference criteria. It is difficult to tell, for instance, if a participant rating of level five (highest realism) means they were indistinguishable from “real” kids or just the most realistic that participant had witnessed to date.

Finally, the sample of 24 participants who completed the questionnaire was not large enough to adequately represent the population. This was further confounded by the fact that half of the participants had teaching experience in a physical classroom while the
other half had no experience. This was confounding as it effectively rendered our study as consisting of two samples of 12 participants in each group.

3.7 Conclusions from Pilot 1

This formative study, spanning case studies, observations, and questionnaires is a foundation from which to launch further research. Findings from this study and the ongoing research can be applied to questions about the viability and optimization of interactive virtual environments for formal learning (Aldrich, 2009; Education Nation, 2012). These findings, including the discrepancies from the behavioral and subjective evidence suggest that the next step should be to integrate objective measures conducted in the area of presence, suspension of disbelief, immersion, and engagement in TeachLivE. Effective measures to be considered for this include physiological measures such as tracking eye gaze and heart rate of users to measure engagement, and response to stress (Nakano & Ishii, 2010; Slater, 2006; Bailenson, 2008). Given the necessary resources, it would be useful to refine the process by including the strategy of expert facial coding, based on the Ekman Facial Action Coding System (FACS) to correlate with physiological and subjective self-report data (Ekman, 2001; Bailenson et al., 2008). The findings of this study contributed to the design of subsequent studies reported in subsequent chapters of the dissertation.
The second pilot study for this dissertation recruited three graduate students (one male, two female) in a training program to prepare them to be future college faculty members. The future faculty members were asked to deliver a lesson to the virtual students in the TeachLivE environment. Each was given the instructions to come with a section of a lesson through which they can practice classroom management and engagement strategies. They were told that they would be delivering the lesson in a classroom of virtual students.

The participants were given demographics questionnaires. They were observed while they delivered their lessons and their behavioral responses to the classroom experience were recorded and coded according to the nonverbal social presence coding categories.

The hypotheses of this research were:

H1: People who feel more social presence will also feel emotionally closer to the virtual students.

H2: Teachers who experience higher levels of social presence will self-report their learning higher.

4.1 Specific Constructs

The constructs in this study were Social Presence and Learning. Social presence is being measured by a behavioral spreadsheet coded by a trained researcher. Recorded
data included physiological data on stress levels and self-reported social presence. The constructs for the second study were reduced to Higher Order Questioning and Specific Praise as the learning constructs. Social Presence was the other construct, which was defined by the exogenous and endogenous factors of social presence. Table 1, shown in Chapter 2, of endogenous and exogenous factors was referenced to track the behaviors of participants in the pilot. The researcher observed and noted instances of the exogenous and endogenous factors: cognitive involvement, social realism, novelty, self-disclosure, similarity, separation anxiety/disorientation, meaningfulness of experience, suspension of disbelief, valence, social action, manipulation, emotional engagement, active/passive social interaction, and flow.

For this segment of the study, researchers focused on factors that were observable. Specifically, the focus was on self-disclosure, suspension of disbelief, emotional engagement, flow, active social interaction, passive social interaction, and social realism. Each of these elements was placed on a coding sheet of Table 1 and the observer recorded each time one of the factors was observed.

4.2 Learner Population Characteristics

The population had little to no collegiate teaching experience. They were graduate students at a state university in Florida and each desired to have a future career as a faculty member at some university or college. Two participants had experience in real classrooms as graduate teaching assistants, while the other did not. This was coded in the demographics data.
4.3 Learning Measures

The learning was measured by self-report in the after action review and by behavioral measures of cognitive gains quantified by frequency of implementation of the target behaviors: higher order questioning and specific praise. Participants were asked to indicate if they felt they learned teaching strategies from the experience. Also the frequency of target behaviors after the training was compared to that of the baseline.

4.4 Procedures / Research Approach

The target learners were graduate level participants of a professional development program, Preparing Tomorrow’s Faculty (PTF) through the University of Central Florida (UCF) Faculty Center for Teaching and Learning (FCTL). These future faculty members registered to gain skills and practice in course design, modes of delivering instruction, learning theories and models, teaching methods, assessment and feedback, professional survival skills, ethics, legal issues, and classroom management. Two of the “future faculty members” had never taught before and two were novices. TeachLivE was used to provide these individuals with additional training and feedback in the areas of delivering instruction, applying learning theory, teaching methods, assessment and feedback, and classroom management.
4.5 Experimental Conditions

The structure of this pilot was a quasi-experiment in which the participants were exposed to a virtual rehearsal in which they were observed in the TeachLivE environment and were then asked to subjectively assess their experience of social presence in the environment.

4.6 Pilot Two Apparatus and Materials Used in Experiment

The experiment required the use of three resources: (a) the overview of target pedagogical skills and a generic lesson plan, (b) the TeachLivE simulated classroom environment, (c) the TeachLivE Reflection System (ReflectLivE), an integrated after-action review system, (d) a coding sheet for behavioral measures of social presence, and (e) a SOIP instrument.

4.7 Pilot Two Instruments and Supplies

The instruments in this pilot included the informed consent form, the social presence questionnaire, the virtual rehearsal reflection form, the TeachLivE presence and perception forms (Appendix C), and the Behavioral Coding Sheet (Appendix D). Participants also brought a copy of their lesson plan and required materials to deliver the lesson.
4.7.1 Delivery

During delivery of the interventions, data was collected at the individual level. Participants were briefed on the purpose of the study and given the informed consent document. On each intervention, they were introduced to the virtual students and told they had ten minutes to deliver their lesson segment. Upon completion of each lesson segment the participants were given the questionnaires and the rehearsal reflection form to complete. They were then debriefed about their performance and instructed on ways to improve, with the opportunity to exhibit such improvement between the first and second interventions.

4.8 Pilot Two Results

There were too few participants for the responses on the questionnaires to be statistically significant. There were only three participants in the pilot study. As a consequence, the results were used to inform decisions on the methodology and approach to the next study.

As far as engagement, two of the three perspective teachers in the pilot study indicated that they felt that the level of engagement with the students was high, they also indicated that their social presence was high. One participant exhibited the signs of social presence, behaviorally, but self-reported not feeling that the students, environment, or experience seemed authentic. This disparity between the self-report and the empirical measure of behavior supports the notion presented in the literature that self-report data are incomplete and perhaps inaccurate.
Initially, participants over-rated the frequency of the desired behaviors. All participants increased in the amount of higher order questioning and specific praise they provided from rehearsal one to rehearsal two. This is consistent with their reports that they felt that they had improved on the skills. This is also consistent with assertions in the literature that simulation and after action review improve on individual self-awareness (Raij & Lok, 2008; Aldrich, 2009).

The students’ feedback in general was positive and they all indicated that they found this to be a useful tool. They also indicated increased self-efficacy from the experience. The feedback of increased self-efficacy even extended to the individual who indicated that the students lacked fidelity.

4.9 Pilot Two Discussion

Overall, the pilot was positive and encouraged the researcher to continue this path of inquiry. Also, this pilot study revealed confounds to be repaired in the dissertation study. One confound that this research revealed was that students who were working with faculty had been primed for the environment. In the interest of minimizing bias, during the dissertation experiment, the population of teachers tested on subsequent studies excluded those familiar with the culture of the virtual technology.

The behavioral observations were consistent with research about nonverbal communication and engagement. In particular, changes in posture that corresponded to authentic emotion were coded. For example, changes from open posture to closed posture as a response to a student’s behavior were noted as a sign of social presence.
When the research began we were measuring higher questions as open-ended versus close-ended questions. We refined the definition of higher order questions to be questions that require synthesis of thought or prior knowledge, as opposed to re-iterating something that the teacher had just explained.

This pilot revealed changes that needed to be made to streamline the study. Participants asked questions about the reflection worksheet, which indicated that some of the items were ambiguous. The questionnaires took a total of one hour for each participant to complete. This amount of time was deemed to be too onerous and, consequently, a potential source of erroneous or at least suspect data.

Also, the number of variables being measured was deemed to be excessive leading us to reduce the number of behaviors to measure for future studies. Eliminating the construct, wait time, also removes the problem experienced in the first pilot with accurately measuring wait time. Finally, we determined that the task that the teachers are given can be more general simply by changing the practice session to one introducing the course to new students.

The inconsistencies between the behavioral measures and the subjective measures demanded the inclusion of a more objective measure. Consistent with the literature, the objective measure that was added to the study is physiological data, by way of a participant’s heart rate (Meehan, Insko, Whitton, & Brooks, 2002; Meehan, Razzaque, Insko, Whitton, & Brooks, 2005). Heart rate was determined to be the most appropriate for this research as it is an established measure for stress, engagement, and social presence. The behavioral measures include a tally of behaviors that literature and empirical research indicate are correlated with social presence while the participant is
teaching in the virtual classroom (Bailenson, Yee, Merget, & Schroeder, 2006; Serby, 2011). Similarly, the physiological measures are taken during the participants’ virtual rehearsal. Finally, the subjective measures chosen for future studies are the social presence instrument and the presence instrument that participants complete after the immersive experience.

The final step of this line of the research is to integrate physiological, behavioral, and subjective measures of presence. The intent of this synthesis is to investigate any potential correlations between these different measures. Additional research in this area can explore the implications of physical changes to the experience of presence and social presence. This may yield analysis of the possibility that these constructs could have mediating or moderating effects on one another as well as on learning outcomes.

Finally, it was realized that the questionnaires and coding forms could be digitized for an iPad or other tablet so that performance could be coded on the tablet so subjects could get more immediate feedback from the metrics measured during their participation. This enables the researcher to present feedback to them in computer-generated form, which participants tend to perceive as more credible and objective than oral feedback which is generally perceived to be subjective.
The focus of this research is to identify the effects of social presence on learning and on self-efficacy, as reported by potential university faculty members who have trained in the Virtual Learning Environment (VLE), TeachLivE to improve their implementation of effective classroom engagement strategies. The faculty members will self-report on perceived social presence, perceived performance, and self-efficacy. This study is an adaptation from the first pilot, as the focus has shifted from physical presence to social presence. Additionally, data will be recorded in observable social presence and learning as demonstrated by improved performance. The inconsistencies observed earlier between the behavioral measure and the subjective measure demanded the inclusion of a more objective measure. Consistent with the literature, the objective measure added to the study is physiological data, by way of participant heart rate (Meehan, Insko, Whitton, & Brooks, 2002; Meehan, Razzaque, Insko, Whitton, & Brooks, 2005). Heart rate was determined to be the most appropriate for this research as it is an established measure for stress, engagement, and social presence. The behavioral measures while the participant is teaching in the virtual classroom include a tally of behaviors that literature and empirical research have shown to be indications of social presence (Bailenson, Yee, Merget, & Schroeder, 2006; Serby, 2011). Similarly, the physiological measures are taken during the participants’ virtual rehearsal. Finally, the subjective measures are the social presence instrument and the presence instrument that participants complete after the immersive experience.
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5.1 Research Questions

1: Is there a relationship between a participant’s perceived social presence and the use of motion control in a VLE?

2: Is there a relationship between a participant’s perceived presence and the use of motion control in a VLE?

3: Is there a relationship between a participant’s behaviorally demonstrated social presence and self-report of social presence in a VLE?

4: Is there a relationship between a participant’s behaviorally demonstrated social presence and autonomic responses that demonstrate social presence in a VLE?

5: Is there a relationship between a participant’s autonomic responses that demonstrate social presence and subjective self-report of social presence in a VLE?
5.2 Research Design

Upon arrival to the research room, the participants completed the informed
consent form and were briefed on what to expect from the study. The participant was
instructed to put on the MIO heart rate measurement instrument. After each participant
was set up and had signed the informed consent, they were introduced to the virtual
students as a teacher visiting to talk about the importance of college. The participants
delivered an 8-10 minute lesson to the TeachLivE virtual students as a baseline. The
participants have one opportunities to deliver the lesson. The participants delivered their
lessons while interacting with the virtual students on the 72” HD monitor, and while
being observed by the researcher and recorded by the TeachLivE Reflection System
(ReflectLivE). The researcher recorded the performance and later coded the behavioral
data for each session. After each session the participant was given the After Action
Review Form to complete. The participant completed the subjective measure of social
presence and the modified Witmer and Singer presence questionnaire.

The independent variable in this study was the motion control by the participant,
enabled by Kinect tracking. The experimental group of participants experienced
TeachLivE with the affordance of movement, in which their motion was tracked by the
MS Kinect and the movements are mapped to control the movement of the virtual camera
so as to represent the movement in the virtual environment. The control group had a
static display and their movement does not affect their view of the virtual space.

<table>
<thead>
<tr>
<th>Static Display Condition</th>
<th>Motion Control by Tracking (Virtual Camera Movement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(No Movement of Virtual Camera)</td>
<td></td>
</tr>
</tbody>
</table>
5.2.1 Empirical: Behavioral Measures: Coding Sheet

Each of the empirical measures for social presence identified in the literature is compiled into a coding sheet for use with observation. The coding sheet instructs observers to record the frequency of the targeted behaviors as shown in Table 5:

Cognitive Involvement/Flow

Emotional Engagement, (laughing, sweating, raising voice, raising hands)

Self-Disclosure

Valence Emotion (intensity)

Suspension of Disbelief

Social Realism,

Social Action (response to agent as if they are a social actor)

Manipulation

Similarity

Meaningfulness of Experience/Similarity to Real World (manifested by constructing a narrative for the student and caring about them)

Novelty (expressing amazement at the technology)

5.3 Constructs

The constructs in this study are motion control (user control of movement of virtual camera to afford movement in the virtual space that is controlled by corresponding movement in the physical space), social presence and learning. Motion control is referring to the tracking the participant’s movement in the TeachLivE lab and
corresponding movement of the virtual camera that depicts the participant’s movement within the virtual classroom. There are two conditions of motion control in the study. In one condition, the tracking moves the virtual camera; in the second condition, the virtual camera remains static (always in the front of the virtual classroom). Social presence is divided into three sub-constructs (subjective social presence, behavioral social presence, and physiological indications of social presence).

The Dependent Variables in this study are the Presence Self Report, Behavioral Social Presence Score, Subjective Self Report of Social Presence, Physiological measure of Social Presence, and Learning (as measured by pre-posttest change).

The independent variable is motion control, translation of user movement tracking with the Microsoft Kinect being translated to control the virtual classroom. There are two levels of the independent variable in this study. Level one of the (IV) is a static display of the classroom that does not include the affordance of movement. Level two of the (IV) moves the virtual camera, which changes the display of the classroom to simulate movement within the virtual classroom around or between the virtual students in the classroom.

Social presence is measured by a behavioral spreadsheet coded by a trained researcher, by physiological heart rate data collected by the Mio Alpha, and by the perception of social presence self-reported on a questionnaire.
5.4 Participants

The participants for this study were active college instructors of undergraduate and graduate students at a mid-sized Southeastern university. These participants were screened to include only individuals who had not been exposed to the TeachLivE environment, as to eliminate familiarity with the technology as a possible confound. Participants elected to complete a professional development activity to improve their teaching. User experience studies are known to be capable of effectively representing 80% of a population with only five participants (Faulkner, 2003). The study was conducted on their college campus, which was anticipated to reduce attrition rates. The original participant pool was 24 and diminished to 20.

5.4.1 Preparing the Participants

The faculty members were instructed to construct a brief (8 minutes) lesson that introduced the virtual students to the idea of why college is valuable. The participants were told that they were part of a career day and to talk to the kids briefly about why college is important. They were encouraged to participate as experience getting exposure to a virtual classroom and to report their perspectives.

The narrative of this segment is that the participants are part of a career day in which multiple people will talk to the virtual students about the value of higher education. “Keep in mind that the virtual students are able to see and hear you, but not to physically interact with you, as they are represented by avatars on a large screen and are not physically in the room.”
5.5 Instruments and Supplies

In addition to the simulation hardware, the participants wore a heart rate monitor that tracked heart rate upon arrival and through the end of their teaching simulation experience. Instruments in this pilot included the informed consent form, an iPad for recording participant performance, the social presence questionnaire, the virtual rehearsal reflection form, the TeachLivE presence instrument, and the Behavioral Coding Sheet. Each participant completed the informed consent upon arrival. The researcher filled out the behavioral metrics during the virtual rehearsal. Each participant completed all the remaining instruments after the first virtual rehearsal and before going through After Action Review (AAR).

5.5.1 Behavioral Coding Sheet as Instrumentation

The Behavioral Coding Sheet created from the social presence factors in the literature was used to collect frequency counts of the behaviors listed that indicate each factor represented. Each of these factors of social presence was from the literature reported in Chapter 2. The coder was instructed to place a mark in the box for each occurrence of the noted behavior during the time frame. In this case, the time frame was 10 minutes. There was a box available for notes to be taken for future consideration, including duration and intensity of the behavior.

In this study, two raters reviewed the video and coded each of the social presence factors in the virtual rehearsal. When the raters did not agree, they discussed the discrepancy until they agreed upon an answer.
<table>
<thead>
<tr>
<th>Factors</th>
<th>Behavior</th>
<th>Frequency</th>
<th>Description (Duration/Intensity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Involvement/Flow</td>
<td>Not noticing the time is up for session. Trying to solve problems that arise in system, attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional engagement (Visible display)</td>
<td>laughing, smiling nervous, sweating, wringing hands, raising voice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Disclosure</td>
<td>Voluntary Disclosure (not solicited)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence</td>
<td>Intensity of emotion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspension of disbelief/Social Realism</td>
<td>Reflexive Responses: saying thank you, please, goodbye, trying to wrap up the lesson</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Action /Social Actor</td>
<td>Respond to virtual student as if they are a social actor in the world and not an agent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manipulation</td>
<td>Navigating the environment to “approach” kids /ask kids to perform physical task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similarity</td>
<td>Reacted in ways that are consistent with human kids (e.g. Try to solve problems)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningfulness of experience/Similarity</td>
<td>Constructing narrative of students/ caring about them</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novelty</td>
<td>Expressing amazement at the technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactivity</td>
<td>Balanced interplay between teacher talk: student talk ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Social interaction</td>
<td>Laughing out loud, talking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Social interaction</td>
<td>Acknowledging the nonverbal behavior of the students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absence (Lack of Presence)</td>
<td>Lack of response or apparent apathy to student behaviors/Trying to break the system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.5.2 MIO Instrumentation

For the inspection of physiological data as a means for biofeedback and engagement, the research team for TeachLivE integrated the MIO heart rate monitor to collect the participant heart rate. This noninvasive approach to gathering the physiological data needed to complete the process of triangulating the physiological indicator of social presence, with the subjective self-report of presence, with the behavioral measure. The MIO was set to report participant heart rate in 30-second intervals.

5.5.3 Social Presence Questionnaire as Instrumentation

The social presence instrument included in this research is the Bailenson Social Presence Instrument from a 2006 study on embodied agents designed to measure social presence. The concise nature of the instrument works well to minimize participant fatigue. Also, the items have been used in the past for a similar research approach of comparing the data from more than one method (Bailenson et al., 2004). The questions on this instrument are delivered with a Likert scale. The questions:

1. I perceive that I am in the presence of another person in the virtual room with me.
2. I feel that the [person OR tutor] in the virtual room is watching me and is aware of my presence.
3. The thought that the [person OR tutor] is not a real person crosses my mind often.
4. The [person OR tutor] appears to be sentient, conscious, and alive to me.
5. I perceive the [person OR tutor] as being only a computerized image, not as a real person.
5.5.4 Modified Witmer and Singer Presence Questionnaire

The presence questionnaire being used for this study is a questionnaire that was created during the pilot by modifying the Witmer and Singer (1999) Presence Questionnaire. The current questionnaire has not been validated upon revision, so that is part of what this study provides. The questions in this instrument are designed for the TeachLivE test-bed, so they omit those related to head mounted display and other irrelevant questions. The modified questionnaire has a high focus on factors of the original questionnaire that are related to social presence. The questions on this instrument are listed below and the complete instrument as seen by participants is included in Appendix D.

1. The TeachLivE classroom feels like a real classroom
2. While interacting with the environment, at what level did you feel like the students were "real" students?
3. During my interaction with the TeachLivE kids, I forgot they were virtual & thought of them as real kids.
4. During my interaction with the TeachLivE kids, I began to understand their different personalities.
5. My ability to move around during the session impacted my interaction with the TeachLivE kids.
6. I noticed ways that these students’ characteristics were not like those of "real" children.
7. It was difficult to interact with the TeachLivE students like I would in a physical classroom.
8. I felt that the TeachLivE students accurately represent the kinds of people that exist in the world.
CHAPTER SIX: RESULTS

This chapter reports the study’s main findings including the presentation of quantitative and qualitative data. This chapter is constructed of five primary sections:

1. Data Screening
2. Descriptive Statistics for the Sample
3. Tracking Condition T-Tests
4. Analysis of Variance Tests
5. Qualitative Findings

6.1 Data Screening

Of the initial 22 participants, two of the participants’ data were discarded to minimize the confounding factor presented by the location of the study changing. Of the twenty remaining participants, 18 of the participants’ data were used, as the heart rate data for two of the participants did not record from the heart rate monitor.

6.2 Description of Statistics for the Sample

Table 6 Gender Breakdown of Participants

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
</table>
The gender breakdown is reflective of the population of the area from which the participants were recruited.

Table 7 Age Breakdowns

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-21</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>22-25</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>26-34</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>35+</td>
<td>8</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 8 Self-reported Ethnicity Breakdown

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Caucasian</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Latino</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Multiple</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Races/Biracial

Table 9 Self-reported Computer Usage

<table>
<thead>
<tr>
<th>Weekly Computer Usage (in hours)</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>31-50</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>51-79</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>80+</td>
<td>4</td>
<td>20</td>
</tr>
</tbody>
</table>
6.3 Comparing Means: Movement Condition T-Tests

The items on the Bailenson Social Presence instrument were given values from 1-7, corresponding with the user response, where the higher numbers were associated with a higher indication of experiencing social presence. The sum of these scores was calculated to provide a composite social presence score. An independent samples t-test was conducted on the social presence composite for participants to evaluate whether their mean was significantly different. The difference of the means for the composite social presence score was not significant between groups, IV Level 1 (M=30.7), IV Level 2 (M = 30), p > 0.05. While users’ subjective self-reports of social presence as described by the Bailenson Social Presence Instrument were not significantly affected by the movement condition; participants in the tracking condition reported a higher sense of being present with another person at a significantly higher rate than those in the non-tracking condition. An independent-samples t-test was conducted to compare responses to Social Presence Instrument Question 1 “I perceive that I am in the presence of another person in the virtual room with me” in the static display condition (IV level 1) and user movement controlled condition (IV level 2). For this item, the participants in this study, there is a significant difference in the scores for IV level 1- static display (M = 6, SD = 0.94) and IV level 2 – motion controlled display (M = 6.6, SD = 0.51) conditions; t (18), p = .05.

The items on the Witmer and Singer Questionnaire were given values from 1-5, where the higher numbers were associated with a higher indication of experiencing presence. The coded items were then added for each participant to create an overall
composite presence score. An independent-samples t-test was conducted to compare the overall score on the Modified Witmer and Singer Presence Questionnaire in the static display condition (IV level 1) and user movement controlled condition (IV level 2). There is a significant difference in the reported experience of presence as reported by the Modified Presence Questionnaire for IV level 1 (M = 32.4, SD = 4.33) and IV level 2 (M = 6.6, SD = 0.51) conditions; t (16), p < .05.

The physical presence specific questions were isolated from the Modified Presence Questionnaire and a new t-test was run on the composite of the physical presence items. An independent-samples t-test was conducted to compare the overall physical presence items on the Modified Presence Questionnaire in the static display condition (IV level 1) and user movement controlled condition (IV level 2). There is a significant difference in the reported experience of presence as reported by the Modified Presence Questionnaire for IV level 1 (M = 6.78, SD = 1.39) and IV level 2 (M = 9, SD = 1.12) conditions; t (16), p < .01.

6.4 Heart Rate Reports

The heart rate data from this study was aggregated and the standard deviations of each participant’s heart rates were calculated to determine variability of the heart rate during the virtual rehearsal session. Looking at standard deviations of heart rates makes them comparable, as it changes the focus from subjective individual heart rates to variations in heart rate. An independent-samples t-test was conducted to compare the heart rate standard deviations of the participants in the tracking condition (IV Level 2) to
those in the non-tracking condition (IV level 1). There is a significant difference in the scores for IV level 1 (M=10.24 SD=3.50) and IV level 2 (M=16.65, SD=10.75) conditions; t (16) =1.75, p = .05. The heart rates of participants in both conditions are shown below; figure 8 displays the static movement condition and figure 9 displays the heart rates of participants in the condition that affords for movement. These visual representations also show the difference in variability of participant heart rates in the different conditions. The complete heart rate report graphs for each participant can be seen in Appendix E.
A multiple regression was run to predict Social Presence Score from the Behavioral Coding Sheet and the Heart Rate Variability score. This multiple regression yielded no statistically significant predictions.

Multiple regression analysis was used to test if the Behavioral Coding Sheet and the Heart Rate Standard Deviation could be used to predict the subjective report of the presence. The results of the regression indicated that the Behavioral Coding Sheet and the Heart Rate Standard Deviations (HRSD) significantly predicted Presence Questionnaire composite scores ($R^2=.27$, $F(1,18)=6.68$, $p<.05$). In this regression analysis, the linear model included the HRSD, but it was not found to be a statistically
significant factor. When the multiple regression analysis was used to test if the Behavioral Coding Sheet could be used to predict the subjective report of the presence (without the HRSD), the results of the regression indicated that the Behavioral Coding Sheet significantly predicted Social Presence Composite scores ($R^2=.74$, $F(1,17)=47.16$, $p<.01$).

### 6.6 Summary of Qualitative Data

This section highlights qualitative data about the participants’ behavior, perception, and reflection on their experiences with TeachLivE. Some of these qualitative elements correspond with elements in the other measures, while others are purely anecdotal.

#### 6.6.1 Qualitative Feedback Related to Social Presence

The factors of social presence became evident while observing participants in the virtual rehearsal and in the interviews. The feedback from users demonstrated cognitive involvement, thinking of the virtual students as social actors, emotional engagement, including voluntary (not solicited) self-disclosure, similarity to physical interactions, and passive interaction. These things occurred, even when the participants were aware of the fact that the virtual students were not real children. One participant in the static movement condition noted, “even though the kids were simulated, I quickly began choosing my words carefully and thinking about their futures.” Though this participant had a significantly lower social presence and presence score in all measures, he was still experiencing high levels of social presence.
This attribution of human characteristics, narratives, motives and agendas was common among the participants, as exemplified by the comment, “I felt like the student in front (Sean) was trying to trip me up, like a gotcha.” Another participant made a more positive attribution of motives, “I felt like the students were starting to have more interest, the more I spoke.”

The connection between participants and the virtual students could be seen very well in emotional engagement and cognitive involvement with the students. Participants treated the kids like they would have treated them in a physical classroom, commenting that, "I didn't get to Maria, I feel bad" and "I feel like that was helpful for the kids".

“I have family members that CJ, Shan, and Ed remind me of. This added a layer of depth that was unexpected.” “It's amazing how the different personalities come through during the presentation.” “Each Student's personality was able to really come through with their interactions.”

Another indicator of the cognitive involvement factor of social presence was when the participants would argue with the kids when they disagreed. Participants often engaged with CJ when she said she didn’t want to go to college, she just wanted to move to Hollywood and do hair. Participants responded with comments such as, "You might need to care about this,” “what path are you going to take in life?” or “I wouldn’t recommend just up and moving to Hollywood.” A noteworthy example of this cognitive involvement and thinking of the virtual students as social agents was when participants tried to discourage CJ from being unkind to Sean. One participant even had the students thinking about their collective futures, "You guys could network with each other and make neat projects…start a business. You have all the right skills between you!"
Learning the personalities of the students also demonstrated social presence, in the sense that participants were suspending disbelief and demonstrating social realism. One participant noted, “I didn’t even consider that they are virtual kids (laughs). I play too many video games.”

Some prime examples of this suspension of disbelief manifesting as social realism were when participants said things to Maria, such as, "I thought you might like to read and write stories." This also was demonstrated when a participant said to CJ, "I'm glad you are interested in this." Another such instance was when a participant noted to Sean, "I hear you like Star Wars." Each of these instances corresponded with a significant increase in heart rate.

Reflexive response, an implicit indicator of social presence, was also common among the participants. Comments like, "I understand what you mean" or “Thank you” were common. Another thing that emerged was a tendency for participants to use minimal encouragers that are typically used in interpersonal communication. Participants encouraged the virtual students to keep talking by saying things like uh huh, and oh really, or nod while the virtual students were talking.

Another indicator of social presence, the factor of noticing passive behavior, emerged in the interviews and in some interactions. One participant noted, "They weren’t paying attention, they were drawing on their desks.” Another participant questioned the virtual students, “Are you doodling?” and subsequently asked, “What are you drawing?” Yet another participant noted, “Their interest in their conversation was visible by their body language, it was wonderful to see how well they interact with you as a presenter."
The social presence factor, social action, emerged frequently as participants would make comments to the students related to the students’ “real lives” in the physical world. "Where are you?" These indicators of thinking of the virtual students as social actors are also associated with another factor of social presence, meaningfulness of experience. Remembering the virtual students’ names is another indicator of social presence, aligned with the factor of meaningfulness of the experience. This also was exhibited when people apologized to the students for not knowing or even for forgetting the student’s name. For example participants would say, “Sorry, I'm bad with names." The two participants who apologized for forgetting student names remembered all five students’ names by the end of the eight-minute virtual rehearsal. The apology for forgetting could also be considered cognitive involvement, as these sorts of apologies are reflexive when interacting with another person.

The meaningfulness of experience factor of social presence frequently emerged in the interview comments after the interaction with comments like, “Sean is my soul mate!” One participant even went as far as to ask “when can I get a chance to mentor Maria?”

6.6.2 Qualitative Feedback Related to Movement Condition

There were anecdotal findings related to motion control that do not emerge in the quantitative data. Most noteworthy of these findings is a tendency for some participants (two) in the static display condition to appear to try to manipulate the environment by moving toward the kids. This corresponded with individuals who demonstrated high levels of social presence in both the subjective instrument and the Behavioral Coding
sheet. This tendency is difficult to generalize, as there were conversely some participants in the motion control condition who moved very little.

It did occur occasionally that a participant walked up to Kevin in the back row. One individual who walked up to Kevin in the back row commented on the loss of immersion when he turned around to walk back to the “front” of the classroom. Conversely, another participant commented, "I didn't use my ability to walk around much, but I think it would have been helpful". But, that user rated the social presence and presence at the highest possible levels.

6.6.3 Qualitative Feedback Related to Fidelity and Realism

Participant perceptions on fidelity and realism also emerged in the interviews. There were multiple comments on the similarity to individual’s own teaching experiences, people they know in the “real” world, and real students. Asserting the similarity to personal experiences in the physical world is another factor of social presence that emerged with feedback from users, such as, “I teach so this was natural.”

The attribution of fidelity and realism were impactful on the user experience, but the visual fidelity was not as much of a factor as behavioral fidelity. One participant noted, "I'm a game designer and an educator, so I understand the impact visuals can have on our acceptance of a character as ‘realistic’. The stylization of these students exaggerated their emotional expression and made it easier to relate to them."

Similarly, another participant noted, “I felt like I was speaking to and interacting with real people speaking through primitive 3D masks with small gestures programmed.”
However, participants commented positively on the behavioral fidelity of the system. “I have a niece in Middle schools and the diverse personalities seem realistic”.

Similarly, another participant commented, “I just did a talk to a group of middle school kids and the ones in the simulated students were literally my group.” Similarity and perception of similarity to the physical world was rated highly, "The different personalities are very well represented and the responses from the students felt unique and custom, not taken from a template." In fact, participants even reported appreciating behaviors that are often considered negative, such as interruptions, “I love the fact that they cut me off while talking. It truly made me feel like it was real”

“The kids felt real, they’ve gotta be real kids.”

"That was spot on to kids characteristics"

“I’m very surprised by the in depth diverse characteristics”

"The representations of the different personalities were very accurate"

Even some of the neutral to negative assertions about the fidelity could be associated with the lower ratings of social presence. Examples of these were comments:

"Kids were too well behaved"

"It was surreal"

“This is not an AI, too smart to be AI”

"Eerie how real it feels"

“If those were not real people, I will be dumbfounded”
Participants reported lack of behavioral fidelity negatively, “The virtual students have no involuntary display of emotion, and this is the most difficult part of reading how a student reacts to a question or feedback.”

**6.6.4 Qualitative Feedback Related to General Experience**

In addition to overall and individual positive ratings of presence and social presence, participants rated the overall experience very highly as well. One participant noted, “I conducted business in a virtual environment for 2+ years and this was a whole new level of immersion.”

<table>
<thead>
<tr>
<th>Table 10 Qualitative Feedback Related to General Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is amazing!</td>
</tr>
<tr>
<td>This was amazing</td>
</tr>
<tr>
<td>That's incredible!</td>
</tr>
<tr>
<td>Highly Impressive</td>
</tr>
<tr>
<td>This could be used to train anyone about anything that involves talking to people</td>
</tr>
<tr>
<td>I enjoyed interacting with the students”</td>
</tr>
<tr>
<td>&quot;The interactions with the class were incredible.”</td>
</tr>
</tbody>
</table>

**6.6.5 Qualitative Feedback Related to Heart Rate**

Heart Rates frequently spiked significantly during certain events, for different people. For instance, when Sean started talking about his interest in Star Wars, one participant’s heart rate went from 60 to 85 in seconds. Another participant’s heart rate
spiked when Sean asked him “What games do you play?” Another participant’s heart rate spiked when Maria asked "what is it like to be a teacher?" For some participants, heart rates increased when the virtual students raised their hands.

Another participant’s heart rate jumped to 89 when CJ said she wants to be rich when she grows up. Heart rates often spiked with self-disclosure, such as, "I love my job," "I love teaching," "my mom is a teacher" and another participant’s heart rate increased when she disclosed that she had dropped out of high school.
CHAPTER SEVEN: ANALYSIS AND SYNTHESIS OF DATA

This chapter discusses the approach to analysis of the data that was collected and the implications of the analysis of the data. This chapter is constructed of six primary sections:

1. Purpose of the Study
2. Analysis of each Research Question
3. Limitations of the Study
4. Implications of the Research Study

7.1 Purpose of the Study

The purpose of this study was to increase contextual knowledge of a hypothesized relationship between the affordance of motion control enabled by translating a participant’s tracked movement to the virtual camera position in a virtual environment. This gives the sense of movement in the simulated world with the intent of increasing the participant’s perceived sense of physical presence and social presence. Additionally, this study examined relationships between subjective, behavioral, and physiological measures of social presence.

7.2 Analysis of Each Research Question

This section explains the findings as related to each of the research questions.
7.2.1 Research Question 1

Is there a relationship between a user’s perceived social presence and the use of motion control in the VLE?

The t-test analysis of the data found a significant difference between the mean scores for the Bailenson Social Presence item 1 between the groups. The mean score for participants in the condition that afforded participant movement was higher than the mean score for the static movement condition. This is seen in the responses associated with the question “I perceive that I am in the presence of another person in the virtual room with me” in the static display condition (IV level 1) and user movement controlled condition (IV level 2). There was a significant difference in the scores for IV level 1 (M = 6, SD = 0.94) and IV level 2 (M = 6.6, SD = 0.51) conditions; t (18), p = .05. This supports the hypothesis that the affordance of motion control by using motion tracking to control the virtual camera in the VLE leads to a higher subjective measure of social presence.

The score for the Bailenson Social Presence Instrument, as a whole, was not significant, which could be explained by the fact that the items on the instrument do not all directly correspond to the type of virtual experience being used as a test-bed in this study. This is supported by the significant results of the social presence items on the Modified Witmer and Singer Questionnaire, as it was modified to be specific to the current study.

Additionally, using heart rate as an indicator of social presence helped to validate the hypothesis. Specifically, the hypothesis is supported by the statistically significant difference between the movement afforded and static conditions. There was a significant
difference in the scores for IV level 1 (M=10.24 SD=3.50) and IV level 2 (M=16.65, SD=10.75) conditions; t (16) =1.75, p = .05. This is also visualized in Figures 8 and 9. There is a statistically significant and visually noteworthy difference in variability of the heart rates in the motion control condition.

7.2.2 Research Question 2:

Is there a relationship between a user’s perceived presence and the affordance of motion control in a VLE?

The hypothesis that a relationship exists between a user’s perceived presence and the affordance of motion control enabled by translating tracking data of participant movement to the virtual camera in a VLE was supported. An independent-samples t-test was conducted to compare the overall score on the Modified Witmer and Singer Presence Questionnaire in the static display condition (IV level 1) and user movement controlled condition (IV level 2). There were significant differences in the reported experience of presence as reported by the Modified Presence Questionnaire for IV level 1 (M = 32.4, SD = 4.33) and IV level 2 (M = 6.6, SD = 0.51) conditions; t (18), p = .05.

While the t-test of the modified Modified Presence Questionnaire composite scores supports the hypothesis, the high frequency of social presence items on the questionnaire may dilute the impact of this finding. To further support this, the physical presence specific questions were isolated and a new t-test was run on the composite of the physical presence items. There were significant differences in the reported experience of presence as indicated by the Modified Presence Questionnaire for IV level 1 (M = 6.78, SD = 1.39) and IV level 2 (M = 9, SD = 1.12) conditions; t (16), p <.01.
This hypothesis was further supported by the qualitative findings. Specifically, comments from participants during the interview support the hypothesis that perceptions of the use of motion tracking to control the virtual camera in the Virtual Classroom, TeachLivE. One example, “I didn't use my ability to walk around much, but I think it would have been helpful.” Another participant commented that “being able to move around really makes you feel more like you are there in the classroom with the kids.”

7.2.3 Research Question 3: Triangulation

Is there any relationship between a participant’s behaviorally demonstrated social presence and self-report of social presence in the Virtual Classroom, TeachLivE?

There was general alignment of the physiological and objective reports. This could be examined in the future with a larger sample size that would allow for correlational analysis. Also, in addition to general alignment of the objective, and subjective measures, there were anecdotal instances of factors of social presence occurring simultaneously with increased heart rate. For example, multiple participants had spikes in heart rate during instances that preceded behaviors that indicate social presence. For instance, heart rates frequently spiked in participants when CJ, an aggressive student or Shawn, a very talkative student, asked a personal question. They also spiked frequently when Maria, a highly introverted student, responded to their questions. Not only does this align the measures, it also indicates a level of fidelity.
7.3 Limitations

There were many limitations to this study that could be improved upon further iteration of the research approach. First of all, the sensitivity of the heart rate equipment was sufficient to get general heart rate data, but not enough to generate Heart Rate Variability (HRV). This limitation may have been the reason why there were mostly anecdotal indications related to heart rate, as opposed to statistically significant quantitative results. Additionally, the novelty of the experience may have had different effects on different participants. Some participants appeared to become immediately immersed in the experience, while others took two and even five minutes to get warmed up. These are potential confounds that may have contributed to heart rate variability. Finally, because there are many factors that could lead to increased heart rate variability, another physiological measure, such as a cortisol measure should be used to validate the tool.

Another limitation was the ambiguity of the Behavioral Coding Sheet for social presence. The form was not as clear as it could have been to facilitate use and generate more inter-rater reliability. Also, some of the factors, upon analysis, were redundant, which further confused the second rater.

7.4 Implications

Social presence and physical presence are impacted by one’s ability to move around in the environment. The fact that this hypothesis is supported informs the use of the MS Kinect or equivalent as a class of valuable yet low cost tools to increase
engagement, which is composed of social presence and physical presence. There are locations and contexts in which TeachLivE tracking is not utilized, due to location or equipment constraints. These findings suggest that the use of tracking whenever possible increases the value of the experience at a significant level. Conversely, it is important to note that, while tracking user movement to control the virtual camera and simulate motion in the virtual environment impacted social and physical presence positively, the levels of social and physical presence in the environment were already quite high. Therefore, it shouldn’t be said that the tracking is necessary; instead that the tracking enhances the experience.

These findings also inform decisions guided by other findings in this domain. Specifically, as it has already been established that physical and social presence are related to learning in a virtual environment and specifically in TeachLivE (Hayes & Hardin, 2014; Straub, Dieker, Hynes, Hughes, 2014), the conclusion can be inferred that movement tracking as described in this research also impacts learning outcomes.

The research design for this project can be used to explore multiple other constructs within this domain. Application of the Proteus effect, in which one’s perception of their embodied representation changes their interaction within the environment (Yee & Bailenson, 2007), could be controlled to explore the impact of the Proteus effect on social presence. Similarly, transformed social interaction can be explored in terms of the teacher’s experience of social presence. As we continue to use virtual schools and virtual classrooms, the concepts of ways to improve the social presence experienced by the teacher delivering a lesson is of increasing importance.
CHAPTER EIGHT: FUTURE RESEARCH

8.1 Physiological

The potential limitations to this study’s use of heart rate data could be addressed with further research. Initially, the inclusion of a baseline measure of heart rate would give more insight into the variability within the experience. Similarly, a more extensive within subjects design study could measure heart rate across participants over multiple trials.

Future research in this area might include a full panel of physiological measures to verify accuracy of each measure. This would address concerns with the potential ambiguity of changes in heart rate being used as an indicator of stress and social presence. This could include EKG instead of just heart rate, to adjust the level of accuracy of the measure and generalizability of the findings. This could also include Galvanic Skin Response (GSR), as it has been used as an indicator of Presence and as a measure of stress as well (Jannsen et al., 2010). Finally, future research might also include cortisol testing to verify changes in the stress hormone. This could validate the GSR and EKG results.

8.2 Behavioral Coding Sheet

The Behavioral Coding Sheet was effective in quantifying characteristics of social presence. The original intention of this coding instrument was to track frequencies of the targeted behaviors that indicate social presence. Upon working with the data, it became
apparent that standardized frequency categories would yield more consistent results. The coding frequencies for this study were translated to frequency categories of high, moderate, low, and null frequencies. Overall there are some elements that are variable within the form, but they were appropriate for the purposes of this research. It is possible to modify this instrument in the instance that some of the variables become less relevant. For example, Manipulation in is dependent on the affordances of the Virtual Experience. Situations in which manipulation is not afforded, do not need to include Manipulation.

Future iterations of this research would benefit from simplifying the Behavioral Coding Sheet. Rather than having a frequency count on each factor, the coding can be done in frequencies of null, infrequent (1-5), or frequent (5+). Simplification would also include simplifying the definitions of each factor on the coding sheet. Not only will this change simplify coding and improve inter-rater reliability, it will also make for a more standardized dialogue about the results. Also, one of the factors of social presence, Absence, should be removed from the form, as it is covered by the other elements. Emotional Engagement and Active Social Interaction should be merged, as they manifest in very similar ways. The factor of manipulation could shift to include if the user makes an effort to manipulate the environment. In the current study, participants in the control condition tried to manipulate the environment before they realized it was not possible. Participants in the experimental condition also manipulated the environment, which was recorded on the Behavioral Coding Sheet as an indicator social presence.

Finally, the entire coding sheet should be digitized and made into an app or integrated into the after action review system, ReflectLivE. Creating a digital version of
the Behavioral Coding Sheet will also allow for customization of factors relevant to a particular study.

8.3 Triangulation

Future iterations of this study might facilitate triangulation by including an item that corresponds to the social presence factors related to the subjective instruments of physical and social presence. For instance, in order for the instruments to serve as validation for one another, there should be at least one item for each of the fourteen factors on the coding sheet.

Also improvements to methods for heart rate collection and the coding sheet could streamline the process for triangulation. Similarly, given the potential for heart rate to represent other cognitive states beyond social presence, an additional physiological measure, such as cortisol testing could increase confidence that changes in heart rate indicate social presence as opposed to physical exertion.

Finally, future research could further validate the Behavioral Coding Sheet by using larger sample size, which would give the statistical power necessary to run regression analysis and correlation analysis on the data to explore if the apparent alignment of measures is an indication of actual correlation. This would also enable the cross validation of the exogenic and endogenic factors of social presence discussed in the literature between subjective measure and the Behavioral Coding sheet.
8.4 Epilogue

The intended contributions of this research were to the understanding of how the affordance of simulated movement in a Virtual Learning Environment would impact the user’s sense of physical and social presence. The results from the current study support the hypothesis that this affordance impacts the experience elements of physical and social presence. Based on these findings, it would be the recommendation of this researcher to include the affordance of movement whenever possible, in mixed reality environments, if presence and or social presence are desired elements of the user experience.

A key contribution of this research is to inform the development of a systematic multimodal framework to measure user experience of social presence and physical presence in a virtual learning environment. The current framework is a streamlined approach to collecting a great deal of data and a systematic process for analyzing and interpreting that data. This approach can yield a great deal of information even in the absence of interviews with each participant, as the qualitative data corresponded with the data from the quantitative instruments. Moreover, this approach can facilitate larger data sets for continued research.

While the specific implications of this study directly address classroom teaching and pedagogical practices, in terms of connection with students, connection with others in a virtual environment is a concern across domains and disciplines. In fact, this generalizes to interpersonal connection across communication mediums, from face to face to virtual. Entire disciplines are built around the concepts of social connection: leadership, sales, and patient care just begin to scratch the surface of the need for
effective ways to evaluate social presence as it is observed and experienced. Both behavioral and subjective reports provide key data and insights into assessing the phenomena of social presence.

The discoveries from using this framework for exploring social presence are not only descriptive, but can also be used to form a prescriptive tool. Aside from the use of the Behavioral Coding Sheet for social presence being useful in describing and assessing behavior in a virtual environment, it can be used to inform individuals on actual versus perceived levels of interaction. Analyzing an individual’s behavior from the lens of the Behavioral Coding Sheet can inform practices that are perceived as absent, as in lacking presence. If this is administered in a physical environment that is known to elicit physical and social presence, the findings can inform an individual’s interpersonal communication behavior.

Finally, through this research and analysis of the phenomena of engagement and social presence, it has become evident that the studies of both of these transcend VR research, transferring to interpersonal communication, whether or not it is mediated by technology. Hence, many of the findings of this research can enhance general understanding of human interactions.
APPENDIX A: INFORMED CONSENT
The Effects of Virtual Rehearsal in Teaching Learning Environment (TLE TeachLivE™) on the Performance and Perceptions of Practicing Teachers

Principle Investigators:
Lisa Dieker, Professor, Child, Family, and Community Sciences, UCF
Charles E. Hughes, Professor, Computer Science Division, Department of Electrical Engineering & Computer Science UCF
Michael Hynes, Professor, School of Teaching, Learning, and Leadership, UCF

Co-Principle Investigators:
Aleshia Hayes, Doctoral Student, Department of Electrical Engineering & Computer Science, UCF

Research Assistants:
Roghayeh Barmaki, Doctoral Student, School of Electrical Engineering & Computer Science

Dear Participant:

Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study that will include practicing teachers because you are currently a practicing teacher.

The research team conducting this research is led by Lisa Dieker, Professor of Child, Family, and Community Sciences; Charles E. Hughes, Professor of Electrical Engineering and Computer Science; and Michael Hynes, Professor, School of Teaching, Learning, and Leadership at the University of Central Florida.
What you should know about participating in a research study:

- Someone will explain this research study to you.
- The research study is completely voluntary.
- You can agree to take part now and later change your mind.
- Feel free to ask all the questions you want before you decide.

Purpose of the research study: This study seeks to improve teacher effectiveness in classrooms by using a mixed-reality simulation called TLE TeachLivETM. We will also be evaluating the use of the TLE TeachLivETM virtual classroom to determine if the model serves as an effective method for professional development.

What you will be asked to do in the study:
During this study, you will be asked to facilitate lesson plans in a minimum of four 10- to 15-minute virtual rehearsals (practice sessions) in a mixed-reality teaching lab called the TLE TeachLivETM Lab. After each of the virtual rehearsals in the TLE TeachLivETM Lab, you will also be asked to participate in an After-Action-Review cycle (AAR) with a trained expert in effective teaching strategies. The AAR will provide you with feedback on your teaching activities during your sessions in the lab and incorporate an opportunity for self-reflection.

Location: The study will be conducted at your school campus.

Time required:
This study will take place in a two-hour session in which you will deliver a lesson to the virtual students for 10-minutes, review a training module, and conclude with another virtual rehearsal. After you complete your two sessions, you will be have AAR, and a feedback survey.

Videotaping:
You will be videotaped during a portion of this study. Videotaping will occur during each of the virtual rehearsals in the TLE TeachLivETM Lab. If you do not agree to be videotaped, you will not be able to participate in the study. Videotapes will be kept in a locked, safe place and only the research team will have access to the recording. The video will be used to provide feedback to you after each of your virtual rehearsals, and you will be able to view the video in order to self-reflect on the teaching strategies you are practicing.

Risks: There are no reasonably foreseeable risks or discomforts involved in taking part in this study, other than those normally assumed as part of your teaching duties. Potential risks may include breach of confidentiality, which is always a risk in data collection. This study is voluntary, and at any time you may opt to discontinue participation in this study.
Benefits: We cannot promise any benefits to you or others from taking part in this research. Possible benefits include an increase in skills related to your performance as a teacher as well as an experience communicating with other individuals.

Confidentiality: We will limit your personal data collected in this study. Efforts will be made to limit your personal information to people who have a need to review this information. We cannot promise complete secrecy. Data will be coded with a personal identification number to keep names confidential. Records of your participation including, but not limited to, consent forms, observation data, and videos will be maintained for at least six years after the study.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has harmed you in any way please contact: Dr. Lisa Dieker, Professor in the Child, Family and Community Sciences, College of Education (407) 823-3885 or by email at Lisa.Dieker@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following reasons:

- Your questions, concerns, or complaints are not answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study: You may decide not to continue in the research study at any time without it being held against you. If you decide to leave the study, contact the investigator so that the investigator can withdraw you from the study. The research study supervisor can remove you from the research study without your approval. Possible reasons for removal include failure to attend the practice sessions, failure to follow instructions of the research staff, or if the research supervisor decides the research study is no longer in your best interest.

☐ I have read the procedure described above
☐ I voluntarily agree to take part in the research
☐ I am at least 18 years of age
☐ I agree to be videotaped

_____________________           ___________      ___________________________
Signature of research participant Date             Printed name of research participant
APPENDIX B: CODING SHEET BEHAVIORAL SOCIAL PRESENCE
<table>
<thead>
<tr>
<th>Factors</th>
<th>Behavior</th>
<th>Frequency</th>
<th>Description (Duration/Intensity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Involvement/Flow</td>
<td>Not noticing the time is up for session. Trying to solve problems that arise in system, attention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional engagement (Visible display)</td>
<td>laughing, smiling nervous, sweating, wringing hands, raising voice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Disclosure</td>
<td>Voluntary Disclosure (not solicited)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence</td>
<td>Intensity of emotion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspension of disbelief/Social Realism</td>
<td>Reflexive Responses: saying thank you, please, goodbye, trying to wrap up the lesson</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Action/Social Actor</td>
<td>Respond to virtual student as if they are a social actor in the world and not an agent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manipulation</td>
<td>Navigating the environment to “approach” kids /ask kids to perform physical task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similarity</td>
<td>Reacted in ways that are consistent with human kids (e.g. Try to solve problems)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningfulness of experience/Similarity</td>
<td>Constructing narrative of students/ caring about them</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novelty</td>
<td>Expressing amazement at the technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactivity</td>
<td>Balanced interplay between teacher talk: student talk ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Social interaction</td>
<td>Laughing out loud, talking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Social interaction</td>
<td>Acknowledging the nonverbal behavior of the students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absence (Lack of Presence)</td>
<td>Lack of response or apparent apathy to student behaviors/Trying to break the system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C: SOCIAL PRESENCE INSTRUMENT (BAILENSON 2004B)
I perceive that I am in the presence of another person in the virtual room with me.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Slightly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Slightly Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

I feel that the students in the virtual room are watching me and are aware of my presence.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Slightly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Slightly Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The thought that the students are not real people crosses my mind often.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Slightly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Slightly Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The students appear to be sentient, conscious, and alive to me.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Slightly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Slightly Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

I perceive the students as being only a computerized image, not as a real people.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Slightly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Slightly Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
APPENDIX D: PRESENCE INSTRUMENT (MODIFIED WITMER & SINGER)
TeachLivE Presence Questionnaire

Instructions: Please circle statement below each sentence that most strongly indicates your response.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The virtual classroom feels like a real classroom.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>2. While interacting with the environment, at what level did you feel like you were interacting with &quot;real&quot; students?</td>
<td>Felt completely real</td>
<td>Felt somewhat real</td>
<td>Felt somewhat fake</td>
<td>Felt completely fake</td>
</tr>
<tr>
<td>3. During my interaction with the virtual students, I forgot they were virtual and thought of them as real kids.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>4. During my interaction with the virtual students, I began to understand their different personalities.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>5. My ability to move around during the session impacted my level of interaction with the virtual students.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>6. These students’ characteristics were not like those of &quot;real&quot; children.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>7. It was difficult to interact with the virtual students like I would in a physical classroom.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>8. I felt that the virtual students accurately represent the kinds of people that exist in the world.</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Don’t agree</td>
</tr>
<tr>
<td>9. How many years of experience do you have teaching in a physical classroom?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. How many hours per week do you use computers?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Have you ever played a game or conducted business in an immersive virtual environment (e.g. Second Life, World of Warcraft)?</td>
<td>Y/N</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please share any unique experiences or things you would like us to know about you related to this project.
APPENDIX E: HEART RATE REPORTS
The graphs of each participant’s heart rates are in the figures below. The heart rates
Figure 13 Participant 7 Heart Rate Graph IV Level 1

Figure 14 Participant 8 Heart Rate Graph IV Level 1

Figure 15 Participant 16 Heart Rate Graph IV Level 1
Figure 16 Participant 15 Heart Rate Graph IV Level 1

Figure 17 Participant 16 Heart Rate IV Level 1
Figure 18 Participant 18 Heart Rate Graph IV Level 1

Figure 19 Participant 1 Heart Rate Graph IV Level 2
Figure 20 Participant 3 Heart Rate Graph Level 2

Figure 21 Participant 5 Heart Rate Graph Level 2
Figure 22 Participant 9 Heart Rate Graph - IV Level 2

Figure 23 Participant 10: Heart Rate Graph - IV Level 2

Figure 24 Participant 11: Heart Rate Graph - IV Level 2
Figure 25  Participant 12 Heart Rate Graph - IV Level 2

Figure 26 Participant 13 Heart Rate Graph - IV Level 2

Figure 27 Participant 19 Heart Rate Graph - IV Level 2
Approval of Human Research

From: UCF Institutional Review Board #1
FWA00000351, IRB00001138

To: Lisa A. Dieker and Co-PI: Charles E. Hughes, Michael C. Hynes

Date: May 13, 2014

Dear Researcher:

On 5/13/2014, the IRB approved the following human participant research until 5/12/2015 inclusive:

Type of Review: IRB Continuing Review Application Form
Project Title: The Effects of Virtual Rehearsal in Teaching Learning Environment (TeachLivE™) on the Performance and Perceptions of Practicing Teachers
Investigator: Lisa A. Dieker
IRB Number: SBE-12-08412
Funding Agency: Bill and Melinda Gates Foundation
Grant Title: N/A
Research ID: N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form cannot be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu.

If continuing review approval is not granted before the expiration date of 5/12/2015, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in IRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziakiewicek Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

IRB Coordinator
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