EXPLORING THE EFFECT OF VISUAL AND VERBAL FEEDBACK ON BALLET DANCE PERFORMANCE IN MIRRORED AND NON-MIRORRED ENVIRONMENTS

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Dedicated to my parents, sister, and best friend. I couldn't have done this without you. Thank you for support and encouragement every step of the way.

Credit: Paul Gordon Emerson

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PRE-FACE

As a professionally trained classical ballet dancer involved in extensive research, I have learned that the two are not mutually exclusive. Together they become a pas de deux: movements dancing in parallel and, at the same time, learning from each other in the creative process. Both exemplify commonalities of discipline, a desire for transcending limits, and an understanding of passion. In the end, they share a common goal: the creation of new discoveries and the responsibility of communicating knowledge. The breakthroughs spark fires within and allow for the pursuit of perfection.

Ever since I walked, I danced. For 15 years I pursued an art form I could not live without and became a professional ballet dancer with the Macedonian Opera and Ballet. My transition to human-computer interaction opened the door to connect ballet and technology. Armed with my love for and know-how of the dance world, I went on a journey to write this piece of work.

ABSTRACT

Milka Trajkova

EXPLORING THE EFFECT OF VISUAL AND VERBAL FEEDBACK ON BALLET DANCE PERFORMANCE IN MIRRORED AND NON-MIRORRED ENIVRONMENTS

Since the 1800s, the ballet studio has been largely unchanged, a core feature of which is the mirror. The influence of mirrors on ballet education has been documented, and prior literature has shown negative effects on dancers' body image, satisfaction, level of attention and performance quality. While the mirror provides immediate real-time feedback, it does not inform dancers of their errors. Tools have been developed to do so, but the design of the feedback from a bottom-up perspective has not been extensively studied. The following study aimed to assess the value of different types of feedback to inform the design of tech-augmented mirrors. University students' ballet technique scores were evaluated on eight ballet combinations (tendue, adagio, pirouette, petit allegro, plié, degage, frappe and battement tendue), and feedback was provided to them. We accessed learning with remote domain expert to determine whether or not the system had an impact on dancers. Results revealed that the treatment with feedback was statistically significant and yielded higher performance versus without the feedback. Mirror versus non-mirror performance did not present any

score disparity indicating that users performed similarly in both conditions. A best fit possibility was seen when visual and verbal feedback were combined. We created MuscAt, a set of interconnected feedback design principles, which led us to conclude that the feasibility of remote teaching in ballet is possible.

LIST OF DEFINITIONS

The terminology used throughout this document follows that provided by Gibbons (2007):

Two modes of communication:

1. Visual – Feedback that includes a full demonstration of the movement that will be performed, image overlay, and facial expressions such as a frown or approving smile.
2. Verbal – Feedback through the use of auditory statements and/or expressions such as “Super!”, “Drop your elbow just a little”, “Gently, smoothly, like going through water, raise your arms to fifth position”, etc.

Two types of feedback:

1. Value – These are words and/or expressions that reveal a judgment.
2. Corrective – These are statements that focus on an error, identify the error and/or correct the error.

The following definitions are our meanings of the level of guidance:

Mirror – Condition that presents the user with a technologically simulated mirror where a reflective image of their dancing is shown.

Non-Mirror – Condition that does not use the technologically simulated mirror. It presents the user with a blank wall in front of which they are to perform. There will be no reflective image of the user.

CHAPTER ONE: INTRODUCTION & BACKGROUND

Introduction to Subject

Judith A. Gray, a pioneer for dance technology once said, "Ballet, an old art is but a young science" (Gray, 1983, p. 34). An affair between art and dance, ballet is a traditional technique that has been developed for centuries, "perfected" into a form with hardly any use of technology. The 500-year legacy of ballet entered a period of decline, as the turn of the 21st century brought a hiatus in its artistic development and innovation (Homans, 2010). This is particularly true for the ballet studio which is composed of three elements: specialized flooring, a barre (a stationary handrail attached to the wall of the studio) and a mirror. Its form has largely remained the same with exception of the dance surface. Dancers spent centuries dancing on wood floors until they evolved to sprung floors in the early 1970s (Looseleaf, 2008). Unlike the flooring, the barre has not changed with note to its evolution. The mirror, on the other hand, has remained a consistent feature. The learning environment of mirror use in ballet likely began in the eighteenth century, although historically the genesis has not been clearly documented (Foster, 1997). A highly technical art form, ballet requires many years of training to perfect the difficult technique. Mirrors become central to a dancer's ballet education due to their ability to present the dancer with a reflective and external image of their performance. The psychology of the dancer is built around the mirror, as it is taught around it. The mirror becomes the source for a

dancer to see how others view them and portrays the success of their technique (Radell, 2013). Studies from Radell & Adame (2003), Dearborn et al. (2006) and Ehrenberg (2010) suggest that mirrors may present negative effects on dancers' body image, level of attention, satisfaction and performance quality. Furthermore, the highest incidence of injuries in ballet have been reported during class (Allen, Nevill, Brooks, Koutedakis & Wyon, 2012). Bad teaching is reported to be one of the causes of injuries (Hoese & McCormack, 2009). Assessing the suggested negative effects of mirrors on dancers and its delay in innovation, a focus is needed to revive the state of ballet to the 21st century. Technology has touched virtually every field except ballet. Researchers have developed various systems and tools to aid dancers, incorporating different types of technologies – such as a large-scale augmented mirror, Kinect-based system, and head-mounted display (HMD) – for ballet training (Anderson, Grossman, Matejka, & Fitzmaurice, 2013, Hallam, McKenna, Keen, Gupta, & Lee, 2014, Marquardt, Beira, Em, Paiva & Kox, 2012, Wang, Turaga, Coleman, & Ingalls, 2014, Yan, Ding, Guan, Sun, Li, and Zhang, 2015.) However, the user interface experience, the interaction, and the feedback design that should be portrayed to dancers has not been extensively studied. The limited academic literature and formal research in this field clearly suggests a significant need to discover how feedback should be portrayed to dancers in order for their ballet technique score and experience to improve. In this study, we design a technologically simulated mirror through which feedback is given to users to evaluate their technique. The purpose is to assess the value of different types of feedback to inform the design of tech-augmented mirrors.

Importance of Subject

1.1 Intellectual Merit

A large number of ideas in this multidisciplinary project, which spans the fields of psychology, design, HCI, and ballet, are new.

Suggesting the negative effects of mirrors on dancers and the lack of feedback from a mirror, more focus should be given to designing effective feedback, whether it be visual or verbal modes of communication, value or corrective feedback, or mirror or non-mirror level of guidance. The extension of this work will expand on previous knowledge about feedback for ballet systems to create a set of design principles. Discovering which kind of feedback helps dancers perform better can inform the design for systems like these, and in turn, innovate ballet and extend its legacy. Subsequently, this type of research has implications for the design of systems for any kind of dance. Going further, and most exciting, is the possibility of making a technical and even artistic assessment of an entire performance, which could potentially benefit ballet competitions and remove the bias of subject matter experts.

1.2 Broader Impacts

This study opens the doors of possibility to integrate technology and the science of rehabilitation therapy, yoga and Pilates, where mirrors are used to indicate performance level. With adequate innovation of systems and a user-controlled capability, systems using – for example, Kinect-based technology –

have the potential to become useful tools for students, teachers, and professionals. In a more advanced stage of development, the level of usability of tools for ballet will increase, if there is a measurement of the speed of movements, a correlation between the movement of head, arms, and feet, and the measurement of posture, balance and weight distribution. This would minimize injuries because the user would be able to understand where they make mistakes and most importantly, how to remedy them. One of the most significant impacts of this research is the creation of healthier and more effective performance environments because feedback is an indicator of performance. Therefore, designing effective feedback design helps users understand how to process, interpret, and learn movement techniques more effectively and efficiently.

CHAPTER TWO: LITERATURE REVIEW

2.1 Mirror and Dance

Studying the effects of mirrors in dancers' perceptions of themselves with regards to their performance and as a guide to self-correction is not new. Studies by Radell & Adame (2003) have suggested that the use of a mirror in a ballet classroom may negatively affect the skill acquisition of the dancer and ultimately impact their performance, which contradicts results from Dearborn et al. (2006). Radell & Adame (2003) separated beginning ballet dancers into a class with a mirror and a class without a mirror. The two classes were recorded performing the same adagio and grand allegro phrase at 5th week and 14th week of both classes. In the end, researchers determined that the non-mirror class had a significant increase in adagio scores, while the mirror class saw no significant increases in the adagio scores or allegro scores. Radell (2012) concluded that while, "85.7 % of dancers remarked that the use of mirrors has influenced their understanding of the concepts taught", satisfaction with overall appearance decreased for high-performing dancers in a mirror class and increased significantly in the non-mirror class. A study by Radell, Adame, Cole, & Blumenkehl (2011) discovered that higher performing dancers had significantly higher satisfaction for body image when they did not use the mirror, while smaller increases were found for both low and high performers in the mirror class. Green has expressed, in a critique of traditional dance instruction, that "the constant focus on an externalized view of the body, as reflected in the mirror, objectifies the dancer's body and requires

students to strive to achieve a specific 'look' while being 'corrected' so the students perform 'proper' dance technique" (Green, 1999, p. 81). While the mirror provides immediate visual feedback in real-time, it also may result in a false perception of a dancer's weaknesses. The consciousness of thoughts contributed by the mirror may welcome detrimental effects in dancers' overall well-being and hinder the development of their technique. Another study by Dearborn et al. (2006) examined the level of attention and satisfaction in 64 college dancers when they learned and performed a simple or a complex dance phrase in a mirror or non-mirror condition. It was found that the dancers in the mirror condition discovered it was most difficult to pay attention when learning and performing the simple phrase. The dancers' learning and performance of both the simple and complex dance phrases in non-mirror condition did not experience any difficulties in their ability.

Mirrors are a type of visual feedback. A study by Notarnicola et al. (2014) examined the effects of teaching with or without a mirror on a specific element in ballet: balance in young ballet students. These preliminary results concluded that the use of a mirror in a ballet studio did not improve the balance acquisition of dancers. However, improvement was discovered after an extended period of 6 months, which confirmed the notion that dancers' motor skills and balance can be easily trained. This was due to the dancers' age, which was in a sensitive development stage where any skill that is worked on can be improved after a certain time period. This study contradicted results from Kim & Kramer (1997), which found that the visual feedback may not prove to be as beneficial once a

particular skill is well-learned. The effectiveness of visual feedback decreased for users in this study over the first three occasions. However, this finding could be due to participants' age. The dancer-mirror relationship was also studied through the dancers' perspectives. A study by Ehrenberg (2010) conducted in-depth interviews with six college dancers and concluded that while mirrors may aid self-correction, dancers felt that there were many negative connotations particularly: the occasional failure of correction via an external image, negative effects on performance quality, critical appraisal and comparison with an unattainable ideal. Studies on mirror and non-mirror have not been extensive. This study aims to contribute to this space to help determine if similar results are found in performance scores in a scenario where feedback is given in a mirror or non-mirror environment.

2.2 Feedback and Dance

While the mirror is the primary source of immediate visual feedback for dancers it does not have the ability to tell students how to correct their mistakes. This is where a teacher is required. Feedback refers to "the information, judgment, or correction given to a student about his or her performance of a task" (Gibbons, 2004, p. 38). It supports three main objectives vital to the development of ballet dancers, "as information to direct error correction, as reinforcement, and as motivation" (Gibbons, 2004, p. 38). Gibbons (2004) also reported that, "performance improves faster with feedback than without it" (p. 38). A study investigating the dimensions of dance teachers' behavior conducted with 157

dancers and 39 dance teachers from Amsterdam School of the Arts concluded that dancers preferred positive reinforcement feedback for correct performance rather than the majority of feedback, which focuses on the student's errors (Van Rossum, 2004).

2.3 Use of Technology to Aid Dancers

In order to provide immediate real-time feedback to users and combat the suggested negative effects of the mirror in ballet instruction, researchers have turned to technology to help aid teachers and students alike. Ballet's traditional approach has been the subject of a new system suggested by Marquardt et al. titled, Super Mirror (Marquardt, Beira, Em, Paiva & Kox, 2012). It is a system developed through the use of Kinect-based technology that "combines the functionality of studio mirrors and prescriptive images to provide the user with instructional feedback in real-time" (Marquardt, Beira, Em, Paiva & Kox, 2012, p. 1619). Anderson, Grossman, Matejka, & Fitzmaurice (2013) compared YouMove, a whole-body, interactive, augmented reality mirror system, to traditional video-based instruction methods and discovered that movement-learning increased using the system. The presentation mode of video-based instruction was challenged by Nakamura, Tabata, Ueda, Kiyofuji, & Kuno as the translational motion, especially the depth direction, can be hard to sense, as well as the timing information when a dancer tries to mimic the video. Researchers then used an image display on a mobile robot to fix this issue. This suggests that

innovations on current methods may be more effective than inventing an entirely new system.

Eaves, Breslin, van Schaik, Robinson and Spears (2011) reported the effects of real-time virtual reality (VR) feedback on motor skills and explored the ability to focus the learner to key features of a to-be-learned action. Most recently, Yan, Ding, Guan, Sun, Li, and Zhang (2015) used the concept of external self-image and presented OutsideMe, a mixed reality system that allows dancers to view their movements through a head-mounted display (HMD) device. They explored atypical modalities such as training with a virtual expert dancer and extra dancer as well as video feedback. A similar HMD tool was developed by Hachimura, Kato & Tamura (2004), which combined mixed reality and motion-capture, as well as a similar system using VR and motion capture developed by Chain, Leung & Komura (2011). However, dance is a movement and as with all virtual reality, dancers are confined to a relatively small area for a short duration as VR causes motion sickness. Dancing with something strapped to their heads can also prevent dancers from performing all of the movements in the way they intended. Therefore, a HMD device has a serious drawback while presenting preliminary positive results that may deter from progression. Most of the aforementioned devices are found in training areas, and in most cases, students do not use them due to their high cost and inconvenience. However, thanks to the evolution of technology, sensors have become cheaper, smaller and lighter. To combat the inconvenience, a study by Wei, Yan, Bie, Wang, & Sun (2014) applied sensors to a smart phone that could “estimate the correctness of motion gesture and rhythm

management by measuring the similarity between the motion data of trainers and the standard data with a dynamic time warping based algorithm". They also proposed an automatic grading system, which could assess the user's performance. After testing, their sensor achieved promising results even when compared to those given by experts. This study suggests the integration of sensors in mobile phones as an alternative tool that can be used by a wider population of dancers across many socioeconomic backgrounds. These findings were reinforced by Parrish (2001) who discovered that inequity is a huge problem, as students fall into the areas of "information-rich" or "information-poor". The issue of fast-evolving technology leaves little room for dance studios to meet demand as these assistive tools are expensive. My study differs from the aforementioned, as it is a bottom-up approach, where the individual base elements, such as feedback, are first studied in order to link together with future studies to form a larger subsystem, which in turn interconnect until a complete top-level system is formed.

2.4 Use of Imagery

Imagery has long been used to enhance learning and focus performance outcomes for dancers. A study by Heiland, Rovetti & Dunn (2012) examined whether college dancers' specific dance skills improved while using different kinds of Franklin images delivered via three approaches, visual, verbal, and tactile. It was found that the visual mode was the most effective of the three. A similar study by Girón, McIsaac, & Nilsen (2012) studied and compared the

effects of visual and kinesthetic imagery during two technical dance movements, plié and sauté. It was found that using imagery to improve performance was task-specific, which meant that some movements benefitted more from it than others.

2.5 Feedback Mechanisms

A study by Ng et al. (2007) developed a multimodal interface with not only visual but also auditory feedback to help aid musicians. Scenarios of sensory multimodal feedback on dancers to become "more immersed in a virtual playground and share the experience of technology not only with the audience but amongst themselves" were explored by Michailidis, Polydorou, & Bullock (2013). Apart from visual and auditory feedback, they add a fourth dimension: haptics. Other research, such as SomaTech by Wang, Turaga, Coleman, & Ingalls (2014), developed a prototype system that "generates real-time auditory feedback from Kinect data, for the purpose of changing people's movement habits". A wearable technology garment, Ballet Hero by Hallam, McKenna, Keen, Gupta, & Lee (2014) was also proposed to not only help aid dancers' learning, but also to support the dancer-teacher relationship by providing visual feedback through the elements of chunking and mirroring. Although formal usability testing was not conducted on the system, a study by Essid, Grenier, Maazaoui, Richard, & Tournemenne (2011) developed an audio-driven virtual dance-teaching assistant, which enabled them to create "augmented tutorial videos highlighting the rhythmic information using, for instance, a synthetic dance teacher voice, but also videos highlighting the steps executed by a student to help in the evaluation of

his/her performance." There is a gap in the literature in regard to studying feedback from systems specifically for ballet.

This multidisciplinary research composed of elements of ballet, psychology, design and technology intends to build upon previous research (Trajkova & Ferati, 2015) and investigate which mode of communication, in comparison with mirror and non-mirror settings, has the best potential for dancers to learn from based on value and corrective feedback. Multimodal interfaces open up new possibilities for ballet education. Discovering which type of feedback is most effective has implications to challenge the current ballet environment, as well as to inform the design of any movement systems such as Pilates, yoga, artistic and rhythmic gymnastics, figure skating, and others.

CHAPTER THREE: METHODOLOGY

This chapter presents the methodology used in the experiment. We first address the user type, then describe the research design and procedures.

Stated succinctly, we investigated feedback via Gibbons (2007):

Two modes of communication:

1. Visual - Feedback that included a full demonstration of the movement that was performed, image overlay, and facial expressions such as a frown or approving smile.
2. Verbal - Feedback through the use of auditory statements and/or expressions such as “Super!”, “Drop your elbow just a little”, “Gently, smoothly, like going through water, raise your arms to fifth position”, etc.

Two types of feedback:

1. Value - These are words and/or expressions that reveal a judgment. These may be specific or non-specific. Value visual feedback involved a projection of the movement along with a facial expression: either a frown or an approving smile. Specific value verbal feedback included, “*Great footwork, you are really pointing your feet now*”, “*Your arms are in first position”, “You did a double turn”, etc.* This kind of feedback is “important to learners on an emotional level” to build confidence. (Gibbons, 2007, p. 58).
2. Corrective - These are statements that focus on an error, identify the error and/or correct the error. Visual corrective feedback included a

demonstration of what was performed incorrectly and how to correct it. Verbal corrective feedback included, “The leap should land on the right foot, not the left”, “Push off the back foot more to finish the pirouette”, “Don’t sit in on your left hip, lift up from underneath”, etc.

We also provide our definition of the level of guidance:

1. Mirror – Condition that presented the user with a technologically simulated mirror where a reflective image of their dancing was shown.
2. Non-Mirror – Condition that did not use the technologically simulated mirror. It presented the user with a blank wall in front of which they performed. There was no reflective image of the user.

3.1 Research Objectives

We conducted a research study structured as a within-subjects experiment followed by an interview-style discussion. The purpose of the study was to assess the value of different types of feedback to inform the design of tech-augmented mirrors.

Specifically, we:

1. examined the impact of mirrors in determining dancer’s performance
2. compared the mode of communication and type of feedback on ballet dance performance.

3.2 Research Questions and Hypotheses

Based on the literature review, we proposed the following research questions:

RQ1: Does the treatment have a significant effect on the execution of the ballet exercises?

Significance: This question referred to the design of our technologically augmented mirror. Before being able to compare different treatments, we needed to make sure that the system we designed was actually effective –i.e., dancers could improve their performances when using it.

Hypothesis: From previous expertise, it was vital to provide feedback on a dancer's ballet technique during the learning process. The dancers were given essential information to help modify their performance. Therefore, our hypothesis suggested that giving adequate and regular feedback would improve the overall execution of the exercises versus no feedback given.

RQ2: Are there conditions that impact the score more than others?

Significance: This question refers to the design of the feedback itself. We needed to determine whether any condition performed better and/or if a particular condition had an impact on the score compared to other conditions, in order to design a more effective system.

Hypothesis: Previous literature suggested that mirror use influenced concepts taught (Radell, 2012), while non-mirror use increased performance scores and body image scores (Radell & Adame, 2003, Radell, Adame, Cole, & Blumenkehl,

2011). From prior experience, mirror-use indicated a heightened sense of self-consciousness particularly in regard to body image. A sense of comfort was felt more with the mirror than without because of familiarity of use. Our hypothesis suggested that non-mirror use would increase ballet technique scores. Differences between value and corrective feedback have not been studied to our knowledge, but as corrective feedback provides more information than value, it was hypothesized that it would perform better. No literature of which we were aware suggested that verbal was more effective than visual feedback, therefore our hypothesis suggested that when combined, it would produce more effective feedback. We were unsure if any other conditions would have an impact.

RQ3: Do users perceive the feedback as overwhelming?

Significance: This question referred to the user-experience of our technologically augmented mirror. We needed to make sure that our design satisfied users and provided feedback that did not overwhelm them.

Hypothesis: The feedback was given continuously in real-time after an error was seen on a dancer. We hypothesized that the feedback would not be overwhelming.

3.3 Participants

Participants were drawn from the population of university students at Indiana University-Purdue University Indianapolis. There were 32 participants in total, of which 30 were female and 2 were male. The general background of users can be seen on Table 3.1. The ratio of participants that had ballet

experience versus those that did not have experience was 50:50. 6 users had 11-plus years of ballet experience. 17 of 32 of users had experience with Kinect. Participants were recruited on the basis that they should be able to move freely and be at least 18 years old. The breakdown of the participant age can be seen in Figure 3.1. Stratified sampling was used, as half of the sample was drawn from a subset of the student population: those with ballet experience. This type of sampling resulted in a greater degree of representativeness by decreasing the probable sampling error.

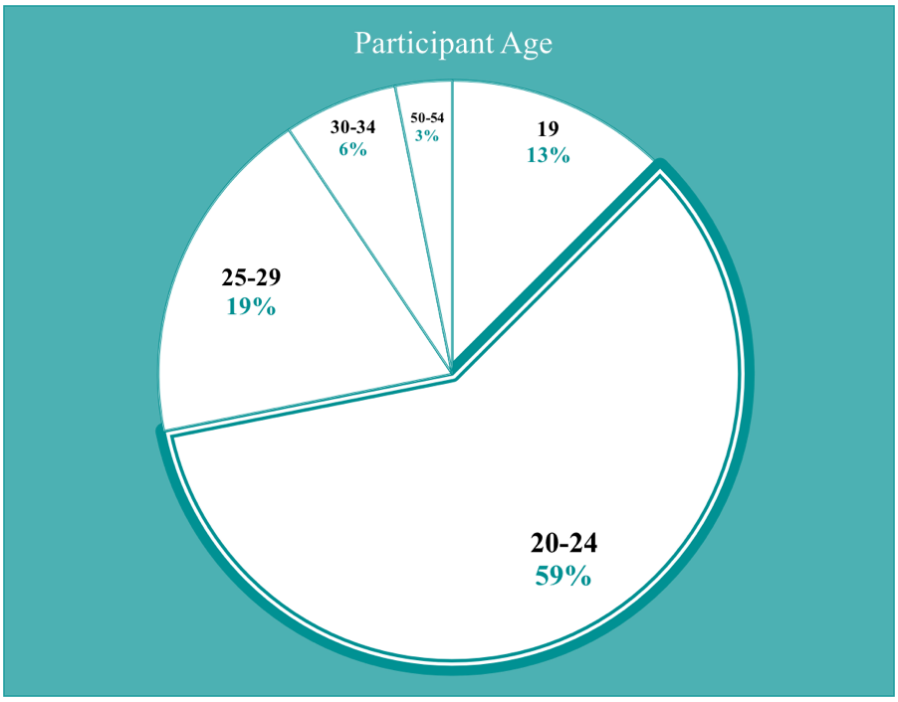

Figure 3.1 Breakdown of participant age

General Background		Users	
		N	%
Ballet Experience	Yes	16	50
	No	16	50
Experience Length	None	16	50
	1-2 months	2	6
	3-4 months	1	3
	1-2 years	2	6
	3-4 years	2	6
	5-10 years	3	10
	11+ years	6	19
Kinect Experience	Yes	17	53.1
	No	15	46.9

Table 3.1 General background information on the participants. Half of the users had ballet experience. Majority of users had at least 11 or more years. 17 of 32 participants had Kinect experience.

3.4 Research Design

A 2x2 within-subject exploratory experimental method was used to compare the users' technique scores in a mirror setting to a non-mirror setting, while they were administered feedback. In order to assess learning, the experiment was divided into a pre-test and a post-test. The pre-test did not provide the treatment (feedback), while the post-test delivered the feedback. The design space seen in Figure 3.2 combined the visual and verbal modes of communication, the mirror and non-mirror level of guidance, and the value and corrective feedback to represent the eight different feedback conditions that were tested. Table 3.2 shows

these conditions. The effectiveness of the feedback was evaluated in two ways, an objective method and user self-reported measurement. The objective method consisted of a ballet teacher evaluating users on the following assessment criteria: Ease of Movements, Mastery of Steps, and Body Alignment provided by the Radell Evaluation Scale for Dance Technique (RESDT) (Radell, 2012). The Ease of Movements scale informed us of how well the movements performed flowed as a holistic piece rather than becoming choppy or disintegrated. Mastery of Steps scale demonstrated how proficient the dancers were in their performance of the movements. Body Alignment indicated how correct the dancers' postures were while performing the movements. Participants were scored on a scale of 1-5, with 1 being the lowest and 5 being the highest possible score. The user self-reported measurement consisted of an adapted NASA-TLX questionnaire with a Likert scale of 1-5 (1 being the easiest and 5 being the most demanding). The questionnaire asked the user to report on their mental demand, physical demand, temporal demand, and frustration after both the pre- and post-test. The questionnaire also asked for an overall effort of the movements. The entire experiment was based on a Wizard-of-Oz approach, wherein the feedback presented to users was displayed using an application interface and partially mediated by a ballet teacher.

	Mode of Communication	Level of Guidance	Type of Feedback	Acronym
1.	Visual	Mirror	Value	VMV
2.	Visual	Non-mirror	Value	VMC
3.	Visual	Mirror	Corrective	VNMV
4.	Visual	Non-mirror	Corrective	VNMC
5.	Verbal	Mirror	Value	VeMV
6.	Verbal	Non-mirror	Value	VeNMV
7.	Verbal	Mirror	Corrective	VeMC
8.	Verbal	Non-mirror	Corrective	VeNMC

Table 3.2 Eight conditions of feedback

The variables for this experiment are as follows:

a) Independent variables: visual mode of communication, verbal mode of communication, value feedback, corrective feedback, mirror level of guidance, non-mirror level of guidance

b) Dependent variables:

   a. Teacher-evaluated score: ballet technique score

   b. Self-reported user satisfaction: mental demand, physical demand, temporal demand, effort, frustration

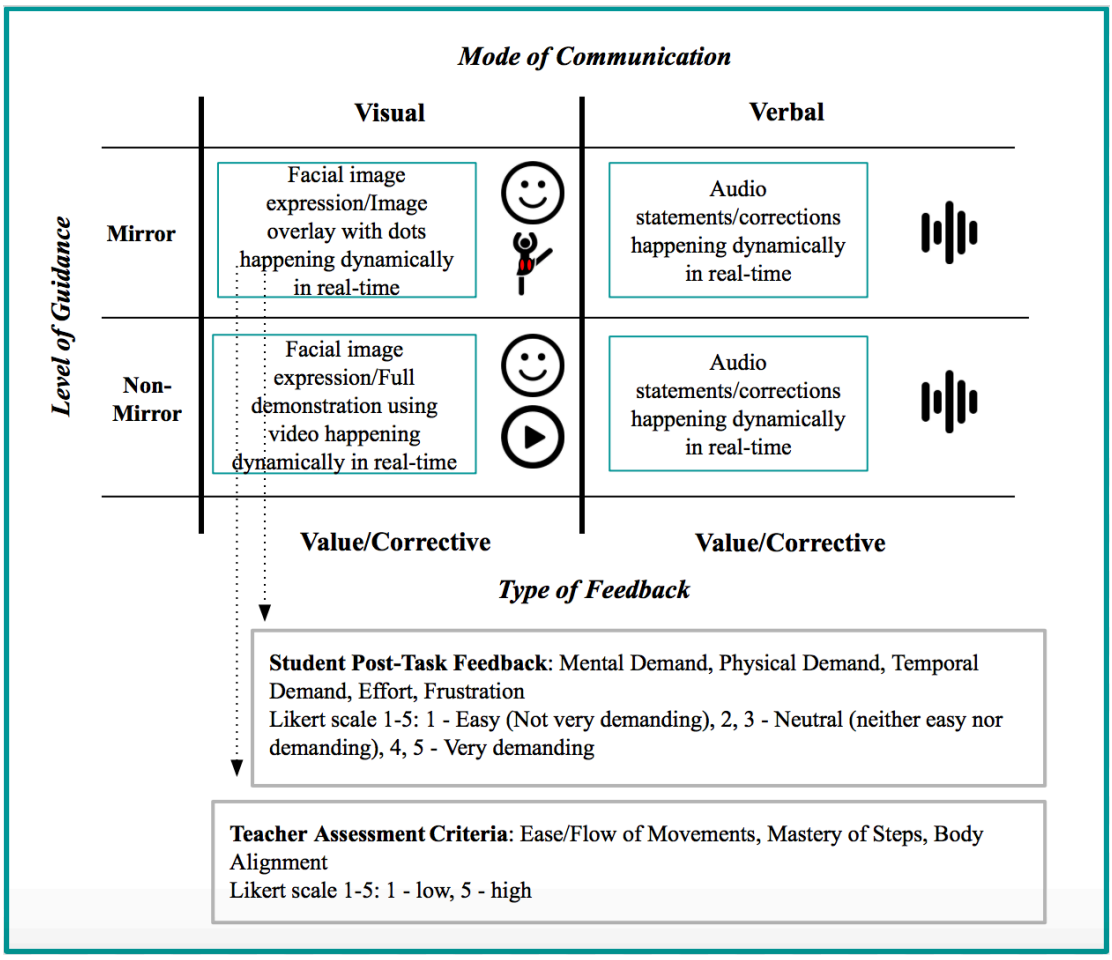

Figure 3.2 The design space combined the visual and verbal modes of communication, the mirror and non-mirror level of guidance, and the value and corrective feedback to represent the eight different feedback conditions that were tested. The effectiveness of the feedback was evaluated in two ways: an objective method and user self-reported measurement. The objective method consisted of a ballet teacher evaluating users on the following assessment criteria: Ease of Movements, Mastery of Steps, and Body Alignment provided by the Radell Evaluation Scale for Dance Technique (RESDT) (Radell, 2012). The Ease of Movements scale told us how well movements performed flowed as a holistic piece without becoming choppy or disintegrated. Mastery of Steps scale told us how proficient the dancers were in performing the movements. Body Alignment informed us of how accurate the dancers' postures were while performing the movements. Participants were scored on a scale of 1-5. 1 is the lowest possible score, while 5 is the highest possible score. The user self-reported measurement consisted of an adapted NASA-TLX questionnaire with a Likert scale of 1-5 (1 being the easiest and 5 being the most demanding). The questionnaire asked for the user to report on their mental demand, physical demand, temporal demand, and frustration after both the pre-test and post-test. The questionnaire also asked for an overall effort of the movements.

3.5 Implementation

The Visual C# application was developed to allow the visual feedback to be displayed when certain letters on the keyboard were pressed by the mediator and the verbal feedback to be heard when the mouse clicked on the buttons. Figure 3.3 depicts this application. The Visual Value feedback can be seen in the black box labeled, 'Feedback'. Figure 3.4 displays the control on the keyboard. The first four rows in the right portion of the screen were the verbal corrective statements. They were color-blocked by the four sets of corrections. The first row corresponded to degage and battement tendue with corrections in the heel, arch and foot. The second row corresponded to the plié corrections, while the third was to frappe and the fourth was general corrections that spanned all four combinations. The number of statements were selected based on the frequency of occurrence and the overall importance. The second section of verbal statements is value. They were color-coded to represent (from left to right): 'Excellent', 'Good', 'Could be better' and 'Needs improvement.' The analogy of representation is similar to a traffic light was a universal color code.

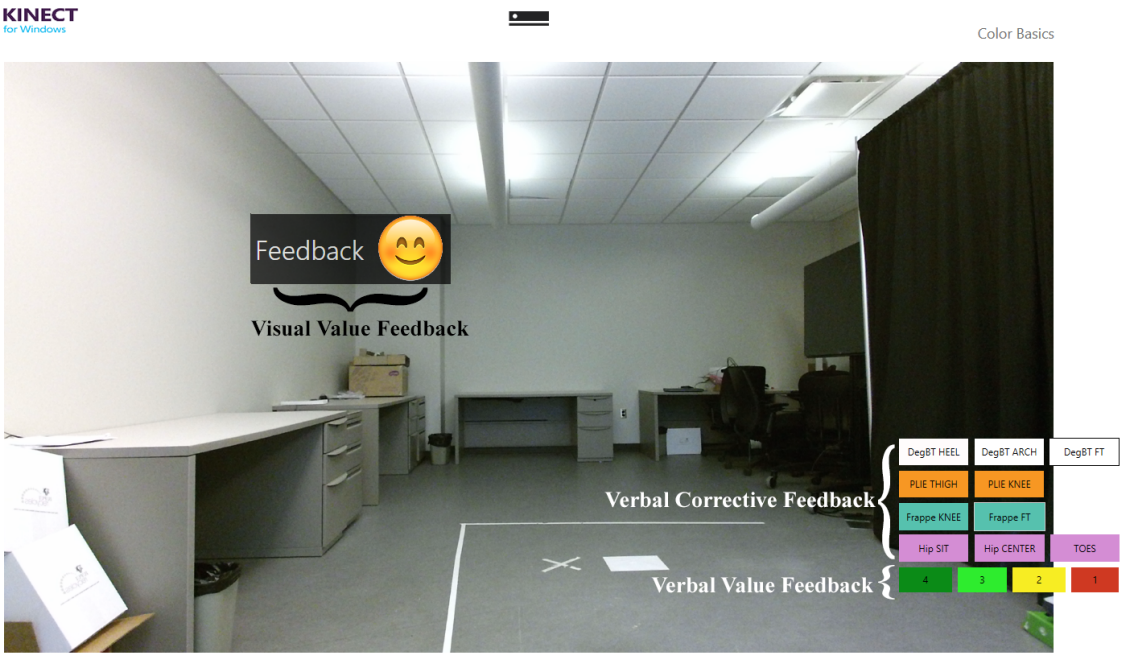

Figure 3.3 A snapshot of the application that was developed using C# in Visual Studio. The Visual Value feedback can be seen in the black box labeled, 'Feedback'.

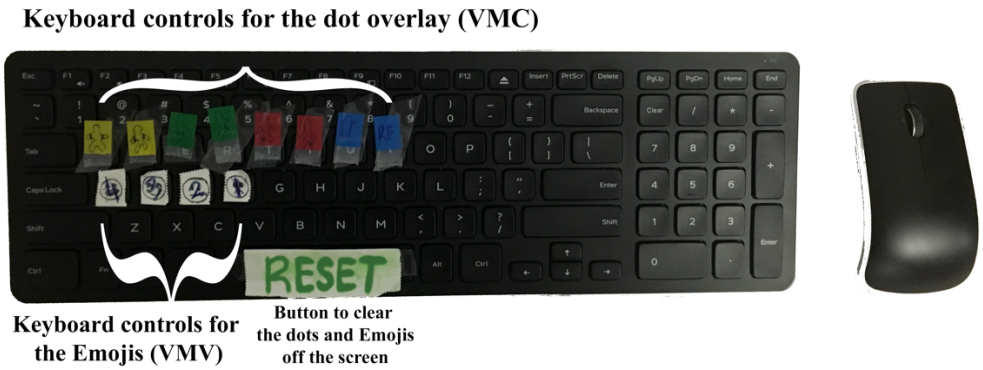

Figure 3.4 Keyboard controls for the application. The first four rows in the right portion of the screen were the verbal corrective statements. They were color-blocked by the four sets of corrections. The first row corresponded to degage and battement tendue with corrections in the heel, arch and foot. The second row corresponded to the plie corrections, while the third was to frappe and the fourth was general corrections that spanned all four combinations. The number of statements were selected based on the frequency of occurrence and the overall importance. The second section of verbal statements were value. They were color-coded to represent (from left to right): 'Excellent', 'Good', 'Could be better' and 'Needs improvement.' The analogy of representation was similar to a traffic light as a universal color code.

3.6 Feedback Design

The initial design space was broken down into value and corrective type of feedback, which was presented to users dynamically in real-time after an error had been identified, as can be seen on Figure 3.5. This meant that each user was presented with feedback every time an error was seen within the time span of the combination. Both the visual mode of communication and verbal mode of communication were broken down into view the value and corrective type of feedback. Each will be described separately.

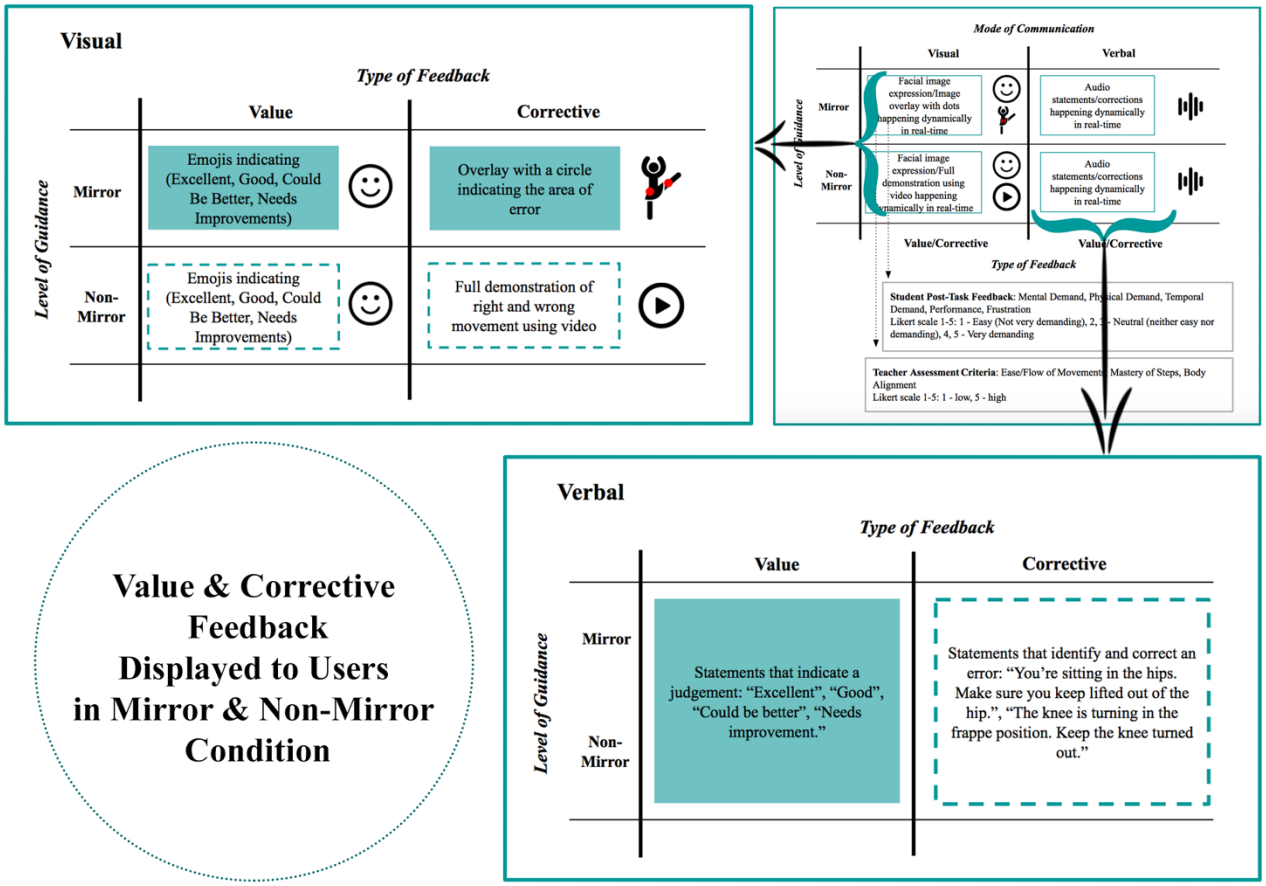

Figure 3.5 The initial design space was broken down to the value and corrective type of feedback that will be presented to users dynamically in real time after an error has been identified. The visual mode of communication breaks off to view the value and corrective type of feedback. The verbal mode of communication breaks off to view the value and corrective type of feedback.

Figure 3.6 depicted how the value and corrective feedback look on the screen.

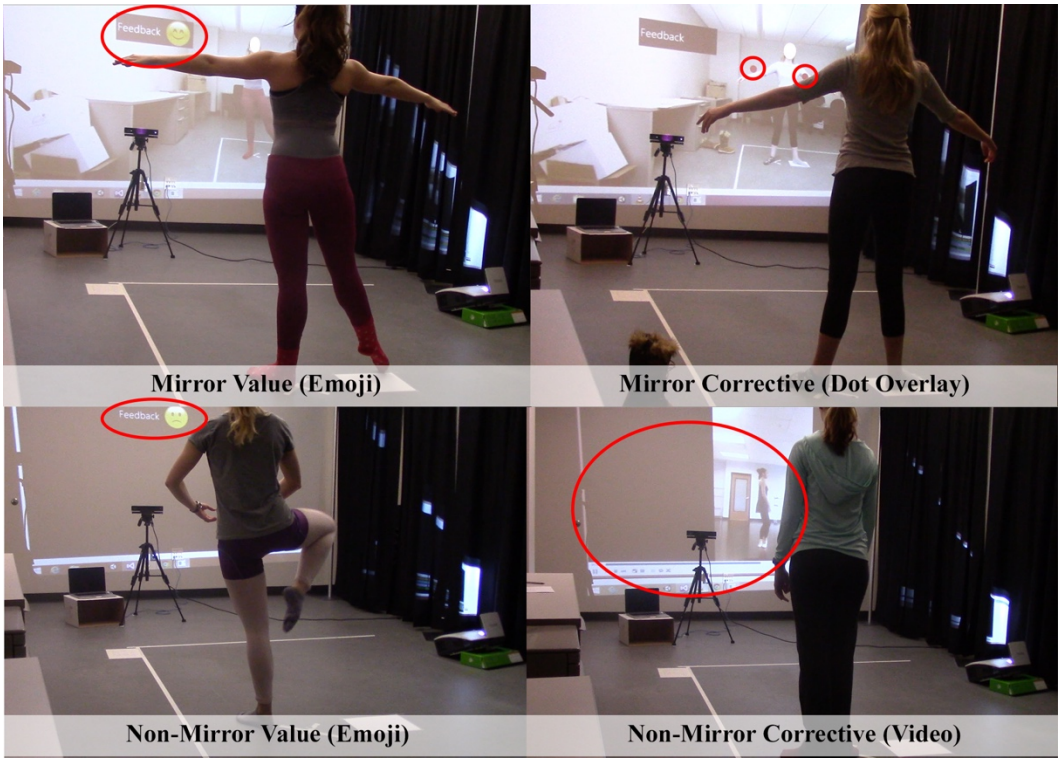

Figure 3.6 Design of value and corrective feedback: mirror value depicted Emojis, mirror corrective displayed dot overlay, non-mirror value showed Emojis and finally non-mirror corrective presented two video: one exhibiting the incorrect movement and subsequently the correct way.

3.7 Explanation of Visual Feedback Design

Figure 3.7 depicted a zoom-in of the visual condition. The mirror and non-mirror value feedback both have a range of four Emojis, which can be seen in Table 3.3.

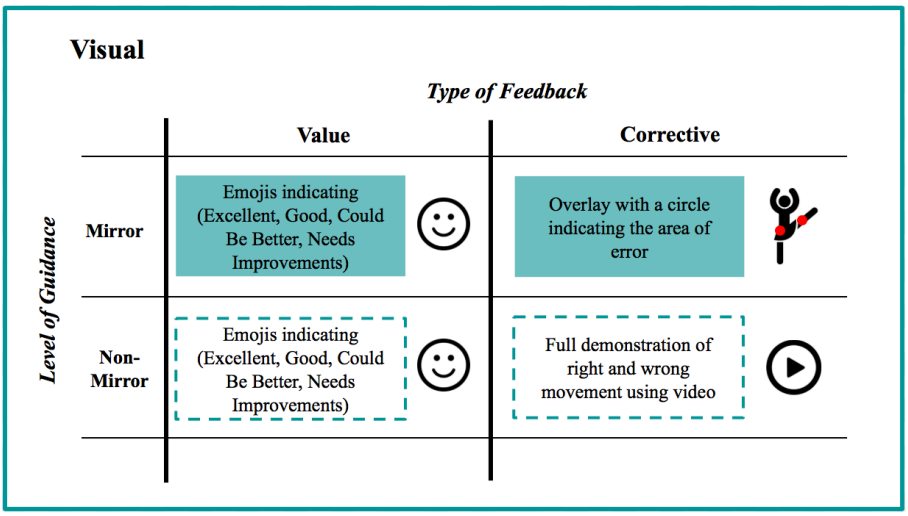

Figure 3.7 Visual mode of communication showing the value and corrective type of feedback that was presented to users in the mirror and non-mirror level of guidance.

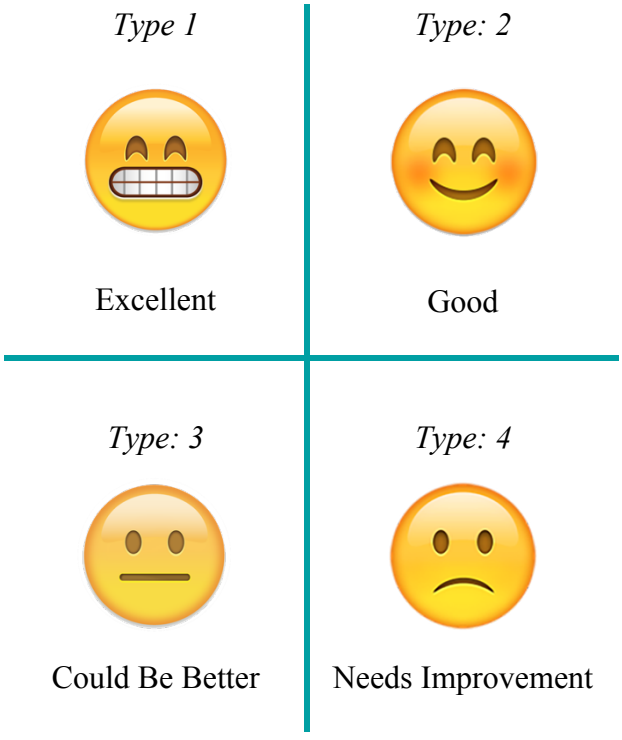

Table 3.3 The four types of Emojis shown in the visual value feedback.

The Emojis depicted facial expressions that denoted a symbol of judgment. These

Emojis were chosen because they have become exponentially popular to interpret emotion since Apple included them on the iPhone (Blagdon, 2013). Emojis were presented dynamically in real-time as the users performed errors. The corrective feedback in the mirror condition present an image overlay with dots to indicate a basic error. The dot overlay was presented dynamically in real-time as the users performed errors. In the non-mirror corrective condition, a video was presented where an incorrect demonstration was shown, followed by a correct demonstration. The incorrect demonstration denoted the performance the user was currently doing, thus identifying the error. The correct demonstration demonstrated how to remedy that error. The video was presented dynamically in real-time as the users performed errors.

3.8 Explanation of Verbal Feedback Design

The verbal condition was presented on Figure 3.8. The mirror and non-mirror value feedback were verbal statements that "[told] learners how you [felt] about what they [had] done" (Gibbons, 2007, p. 58). Value statements included, "Excellent", "Good", "Could be better" and "Needs improvement". These statements were also given dynamically in real-time when the teacher identified an error. Corrective statements identified the error and provided a correction. Examples included,

"Your toes are not pointed. Please keep your toes pointed."

"Your heel is turned in. Make sure that the heel moves first for the brush out and the toes meet the floor first when closing."

"Your inner thighs are turning in. Keep the inner thighs turned out when ending the plié."

A list of one to three verbal statements for each movement was created for the system.

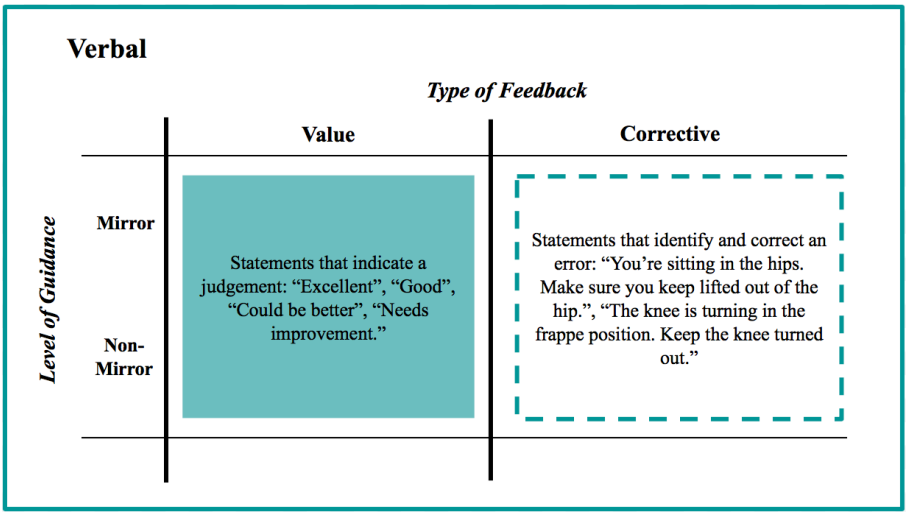

Figure 3.8 Verbal mode of communication showing the value and corrective type of feedback that will be presented to users in the mirror and non-mirror level of guidance.

3.9 Ballet Combinations

Eight separate ballet combinations were choreographed and assessed by the ballet teacher, Chivvaun Smith – who has a Bachelor's degree in Ballet Pedagogy – for the visual and verbal conditions. The descriptions of each were shown in Figure 3.9. Four ballet combinations were in the visual condition and four were in the verbal condition. There were differing combinations for each condition to avoid a learning effect and allow randomization to occur. We randomized each set of visual combinations and verbal combinations using a random number generator. Each combination was carefully choreographed by the

ballet teacher to ensure that they had similar difficulty levels. Although, the same evaluation was used for beginner and expert users, the ballet teacher scored expert dancers with a higher expectation of their technique versus the beginners who were scored accordingly. We chose these eight combinations because they are beginner-level combinations that, regardless of experience, all participants would be able to do. Each combination was performed according to a predetermined number of times, which would have occurred in a regular ballet class environment. All the combinations were performed twice except the pirouette which was repeated three times in each pre- and post-test condition.

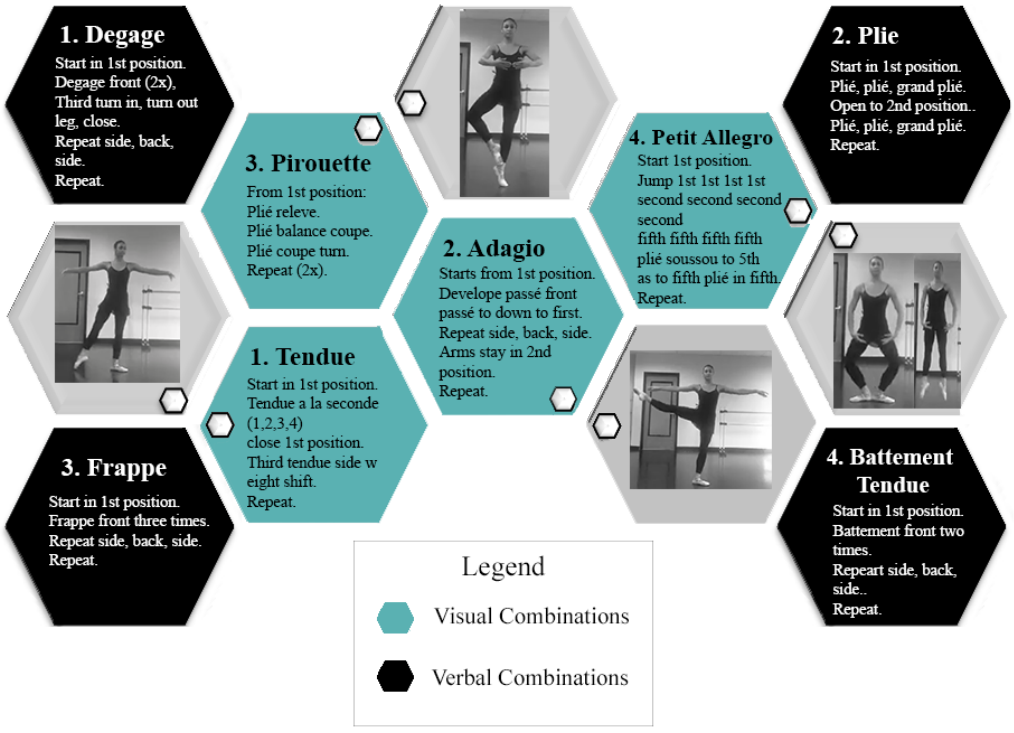

Figure 3.9 Description of ballet combinations used in the experiment. Four ballet combinations were in the visual condition and four were in the verbal condition. There were differing combinations for each condition to avoid a learning effect and allow randomization to occur. We randomized each set of visual combinations and verbal combinations using a random number generator.

3.10 Set-Up

The experiment took place in the researcher's lab – IT 266 – a wide room, which most closely resembled a ballet studio. The set-up of the room can be seen in Figure 3.10. The Kinect was set up in front of the user to capture their reflection. The laptop served as a mediator between the teacher and the user, where a Skype connection allowed the teacher to remotely view the user. The laptop was dimmed so the user could not view the screen. The projector served to project the feedback which was connected to the computer. A curtain divided the user from the mediator so the user could not see the mediator. The user performed in the 'X' marked area and was situated in front of the Kinect. The video recorder was set up behind the user so it could safely de-identify her yet capture her movements and her head position of the feedback.

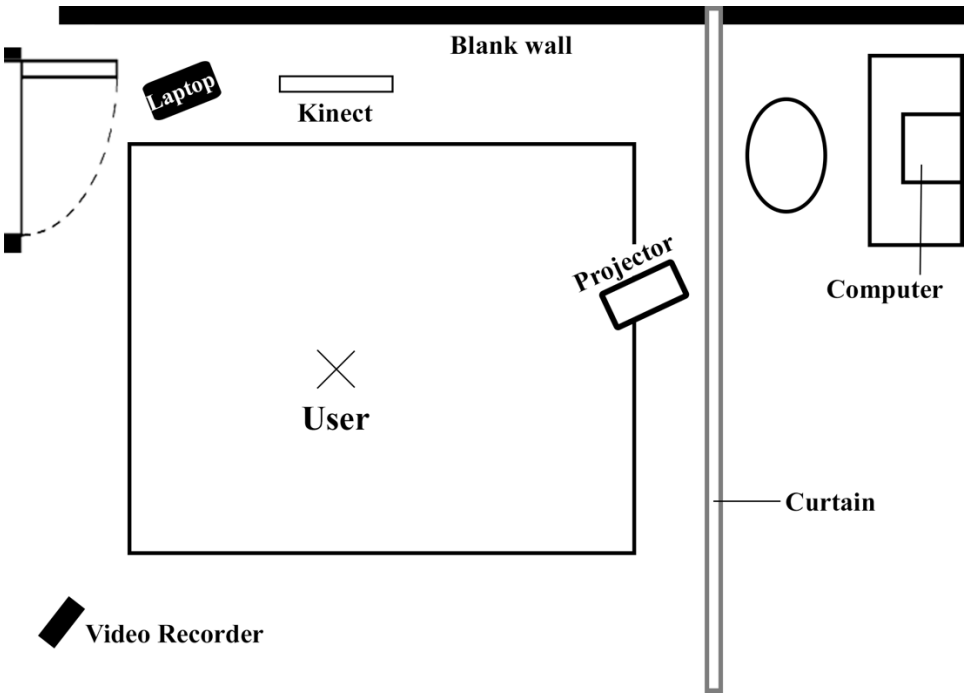

Figure 3.10 Room equipment set-up for the experiment.

During each session, one individual student was taught the ballet combination. She performed either in front of our definition of a mirror – a Kinect – or a non-mirror – a blank wall. Each user was presented feedback via two modes of communication, a visual projection of the movement and verbal or pre-recorded reminders to aid them as they performed. These modes of communication were delivered by two types of feedback, either value or corrective. Table 3.4 presented the value and corrective feedback given to users in the mirror and non-mirror conditions.

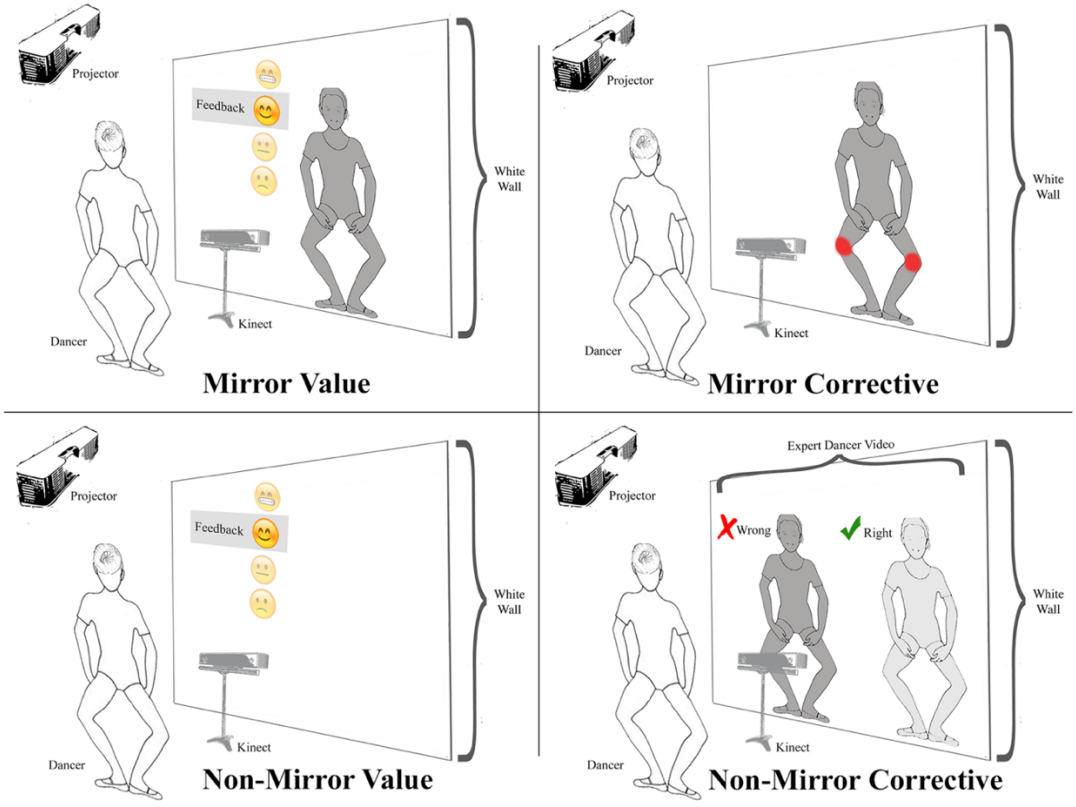

Table 3.4 The mirror and non-mirror conditions showing the value and corrective feedback that was displayed to users dynamically in real-time.

We videotaped each session to qualitatively evaluate the performance level of the students. Via Skype, a ballet teacher watched, communicated with a mediator, and evaluated the performance level remotely. The mediator wore headphones to communicate with the ballet teacher in order to present the feedback to users. A post-task NASA-TLX questionnaire was administered at the end of each session to obtain feedback from users about the mental demand, physical demand, temporal demand, effort, and frustration following both the pre- and post-tests. After the entire experiment concluded, the user was asked a few open-ended questions in an interview about their experience. Some of these open-ended remarks will be used directly as quotes.

3.11 Procedure

The methodological approach consists of the following steps tested on participants, which are presented in Figure 3.11. Each test was composed of four conditions and four combinations either in the visual condition or verbal condition. Each combination was performed enface (to the front) according to a number of times predetermined by the ballet teacher. This number was due to the artistic nature of ballet. It was necessary and essential to mimic the number of times each movement was performed as it would be in a typical ballet class to create, as closely as possible, its natural environment. All the combinations were repeated twice. Intentionally, each dancer began with alteration, either with visual feedback or with verbal feedback to nullify any possible practice effects of the dancer to accustom to the system. Each combination was randomized using a random number generator to avoid any learning effects. Each combination

consisted of two sequences: pre-test and post-test. The pre-test condition did not administer any feedback. The post-test condition administered an ordinal order of feedback conditions. Between each condition, a one-minute break was given to allow for rest. The teacher evaluated each sequence and assessed the student's performance on a scale of one to five based on a set of criteria found in Figure 3.2.

Testing the dancers involved setting up the Microsoft Kinect, connecting to Skype with the ballet teacher, turning on the projector, and opening up the program.
A pre-test questionnaire was first distributed to the participant to capture certain demographics such as age, for how long they have been dancing ballet, if they had had experience with Kinect, etc. After each sequence, a post-task questionnaire was administered to the participants.

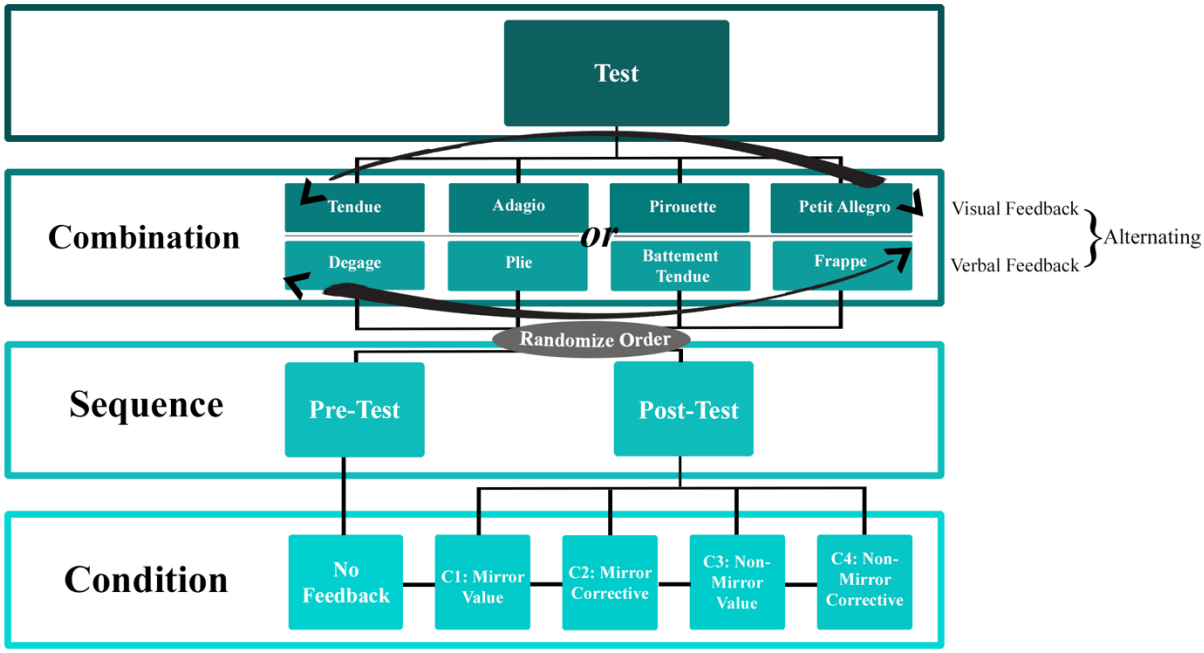

Figure 3.11 Procedure of testing one participant: Each test was composed of four conditions and four combinations either in the visual condition or verbal condition. Each combination was performed enface (to the front) according to a number of times predetermined by the ballet teacher. This number was due to the artistic nature of ballet. All the combinations were repeated twice. Intentionally, visual and verbal feedback would alternate to avoid practice effects. Each combination was randomized in order to avoid a learning effect. Each combination consisted of two sequences: pre-test and post-test. The pre-test condition did not administer any feedback. The post-test condition administered an ordinal order of feedback conditions. Between each condition, a one-minute break was given to allow for rest. The teacher evaluated each sequence and assessed the student's performance on a scale of one to five.

3.12 Data Analysis

The data analysis used different statistical tests in order to determine if the difference between conditions was statistically significant at 95%. Our first research question inquired if dancer's ballet technique score improved when using the feedback. An independent-sample t-test was conducted to compare ballet technique scores in pre- and post-test conditions. The second research

question inquired if any condition (mode of communication, level of guidance or type of feedback) had a significant impact on the ballet technique scores. We separated this question into two parts. A MANOVA was first conducted that compared the effect of one independent variable (feedback) on ballet technique scores. The feedback type consisted of eight levels (Visual Mirror Value, Visual Non-Mirror Value, Visual Mirror Corrective, Visual Non-Mirror Corrective, Verbal Mirror Value, Verbal Non-Mirror Value, Verbal Mirror Corrective, Verbal Non-Mirror Corrective). In order to increase our sample points, we separated our feedback conditions and grouped each type of feedback by condition. In this way, we were able to run t-tests for each condition. An independent-sample t-test that was conducted to compare the score in the mode of communication (visual and verbal) condition. We also ran an independent-sample t-test to compare the score in the type of feedback (value and corrective) condition. A final independent-sample t-test was conducted to compare the score in the level of guidance (mirror and non-mirror) condition. Our third research question inquired if the overall workload elicited a significantly higher post-test workload than pre-test across all the conditions. We plotted the pre-test and post-test NASA-TLX scores on a line graph to visualize the workload difference. The qualitative data (e.g., interview and video) was coded and converted into quantitative measures for similar analysis. See Figure 3.2 for a concise listing of the data that was collected.

3.13 Ethical Considerations

We anticipated that privacy would be an issue, as data is collected about participants. To remedy this, all identifiers were removed. Audio/video recordings were made of the focus group and stored on electronic media. When not being used for transcription, this media was kept in a locked cabinet. Transcription and coding of the recordings were performed by the research team. After transcription was completed, the files were deleted.

CHAPTER FOUR: RESULTS

In this chapter, we present the findings from our experiment. The results are reported in three main sections. Section 1 will present a quick overview of prior research and methodology, Section 2 will present the results pertaining to research question one, two and three.

4.1 Overview on Prior Research

Prior research recognizes that reflection and feedback are vital elements in dance and help to inform future action (Chen, 2001; Cone & Cone, 2005; East, 2005; Gibbons, 2004; Lavender, 1996; Lavender & Predock-Linnell, 2001). In recent studies by Muneesawang et al. (2015), Sun et al. (2014), Chan., Leung, Tang, & Komura (2011), Alexiadis et al. (2011), researchers designed their system's feedback to train dancers by means of either a visual mode of communication – a side-by-side or overlay imitation of a teacher's movements – visual representation of the score, immediate color overlay error indication, or slow-motion replay. However, there is a lack of empirical research from the user point-of-view that explores how the methods of feedback in traditional teaching can be effectively applied to technological systems, such as Kinect. There is little documented other than that of Gibbons (2004), who suggested that feedback should be offered by verbal, visual or kinesthetic approaches in the traditional studio setting. Additionally, past studies have conducted user studies with a low participant number which did not allow for a generalization of the results. Moreover, previous systems designed for ballet did not necessarily include the proper user group as is needed to properly provide evidence that the system is

useful. This exploratory work attempts to understand the implications for designing feedback in systems for ballet.

In our study, ballet technique scores were measured by three independent variables, the type of feedback, mode of communication and level of guidance, which were obtained by the means of a controlled Wizard-of-Oz experiment. Participants were instructed to perform four ballet combinations of a similar level in a pre-test and post-test trial with the two types of feedback, visual and verbal. In the post-test, they were exposed to one of the two modes of communication, value or corrective, which were presented at continuous rates.

4.2 Data Analysis Findings

This section reports the results from the one-way repeated measures ANOVA, which measured the effect on performance. Findings from independent t-tests were also reported, which measured whether or not the treatment had an effect on the performance and if any condition had an impact.

4.3 Effect of Feedback on Ballet Technique

Our first research question inquired whether or not the treatment, a composite variable of the mode of the communication (visual and verbal), the type of feedback (value and corrective), and the level of guidance (mirror and non-mirror) had a significant effect on the ballet technique score. An independent-sample t-test was conducted to compare ballet technique scores in pre- and post-test conditions. There was a statistically significant difference in the scores for

pre-test (M = 2.72, SD = .696) and post-test (M = 2.96, SD = .778) conditions; t (1534) = -6.518, $p < .001$. Figure 4.1 represents the means of the scores for each of the pre-test and post-test conditions. This indicates that the treatment was effective because the mean difference of all the post-test scores in all the conditions was higher than all the pre-test scores in all conditions. It is worth noting that the pre-test conditions indicated scores without the feedback given, whereas the post-test indicated scores with the feedback given. In the pre-test, users performed just the combination with no feedback given. Afterward, in the post-test, users performed the exact same combination, only this time, they were administered feedback. We predicted that this would have a statistically significant effect on the difference in scores on the execution of ballet exercises. We did not imply that all treatments were equally effective due to lack of literature, but rather, we suggested that the overall combined feedback had an impact. The treatment was effective therefore, our hypothesis was confirmed.

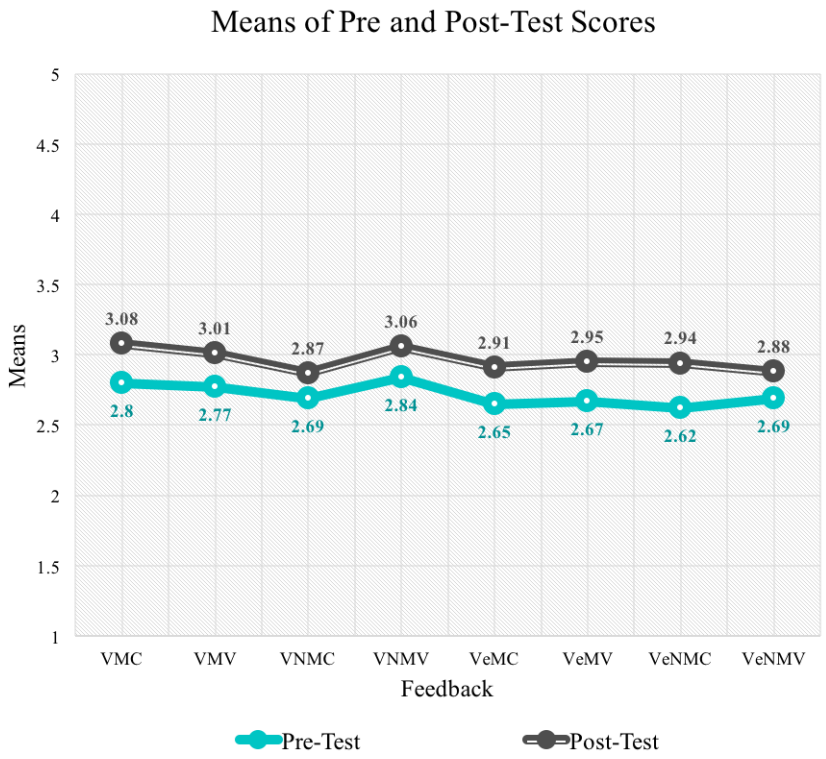

Figure 4.1 Comparison of pre-test scores (scores without feedback) and post-test scores (scores with feedback). The mean difference of all the post-test scores in all the conditions was higher than all the pre-test scores in all conditions, which indicate that the treatment was effective.

4.4 Impact of Conditions on Score

The second research question inquired if any condition (mode of communication, level of guidance or type of feedback) had a significant impact on the technique scores. We separated this question into two parts to present the results. The first part determined whether there was feedback that impacted the score more than others. MANOVA was performed to compare the effect of one independent variable (feedback) on technique scores. Feedback type consisted of eight levels (Visual Mirror Value, Visual Non-Mirror Value, Visual Mirror Corrective, Visual Non-Mirror Corrective, Verbal Mirror Value, Verbal Non-

Mirror Value, Verbal Mirror Corrective, Verbal Non-Mirror Corrective). An analysis of variance indicated that the effect of feedback on the score was significant, $F(7, 1528) = 2.018$, $p < .05$. This showed that the level of feedback had an impact on score. A post-doc turkey test did not indicate any significance, which could be due to sample size when considering all of the feedback types together.

The second part examined whether there were conditions that impacted the score more than others. In order to increase our sample points, we separated our feedback conditions and grouped each type of feedback by condition. In this way, we were able to run t-tests for each condition. We grouped each type of feedback by condition: visual vs. verbal, value vs. corrective and mirror vs. non-mirror. We did not run multiple t-tests on different experimental conditions (e.g., VMC vs. VMV and VMV vs. VMNC), which would require an ANOVA instead. An independent-sample t-test was conducted to compare the score in the mode of communication (visual vs. verbal) condition. There was no statistically significant difference in the scores for visual ($M = 3.01$, $SD = .739$) and verbal ($M = 2.92$, $SD = .814$) conditions; $t(766) = 1.509$, $p = .132$. An independent-sample t-test was conducted to compare the scores among the types of feedback (value and corrective). There was no statistically significant difference in the scores for value ($M = 2.97$, $SD = .801$) and corrective ($M = 2.95$, $SD = .755$) conditions; $t(766) = .394$, $p = .694$. An independent-sample t-test was conducted to compare the score in the level of guidance (mirror and non-mirror). There was no statistically significant difference in the scores for mirror ($M = 2.99$, $SD = .744$) and non-

mirror (M = 2.94, SD = .810) conditions; t (766) = .904, p = .366. Table 4.1 shows the results from the t-tests. There is a possibility that some conditions (e.g. mirror vs. non-mirror) do not impact the learning outcome. Our hypothesis that non-mirror use as well as corrective feedback would increase scores was inconclusive. Future work should consider a bigger sample to suggest if any difference in separate conditions has an impact.

		Levene's test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
CONDITION: Mode of Communication (Visual and Verbal)	Equal variances assumed	2.222	0.136	1.509	766	0.132	0.085	0.056	-0.025	0.195
CONDITION: Type of Feedback (Value and Corrective)	Equal variances assumed	0.692	0.406	0.394	766	0.694	0.022	0.056	-0.088	0.132
CONDITION: Level of Guidance (Mirror and Non- Mirror)	Equal variances assumed	2.538	0.033	0.904	766	0.366	0.051	0.056	-0.059	0.161

Table 4.1 Independent t-tests on each set of conditions: mode of communication, which included visual and verbal, type of feedback, which included value and corrective, and level of guidance, which included mirror and non-mirror. No significant results were found.

It becomes interesting to visually represent the means for each condition to get a better idea of where users were getting a higher score. Figure 4.2 depicts the difference in technique scores for each of the conditions. Although no statistically significant difference was found in the score for visual and verbal, it is worth noting that participants performed higher for visual feedback (M =3.01, SD = .74) than for verbal feedback (M = 2.92, SD = .81). Future work will determine if visual or verbaol plays a particular role for the score if participant size increases. As we can also see, users performed only .05 better in the mirror condition than the non-mirror. There was only a .02 difference in value and corrective. Differences in the type of feedback (value and corrective) were also not significant, as well as the level of guidance (mirror and non-mirror). Although, we can see that mirror scores (M = 2.99, SD = .74) were almost equal to no-mirror scores (M = 2.94, SD = .81). Value feedback scores (M = 2.97, SD = .8) were slightly higher than corrective feedback scores (M = 2.95, SD = .76). This result suggests that tech-augmented mirrors are better than standard ones in terms of learning.

These findings will be corroborated in the discussion section below.

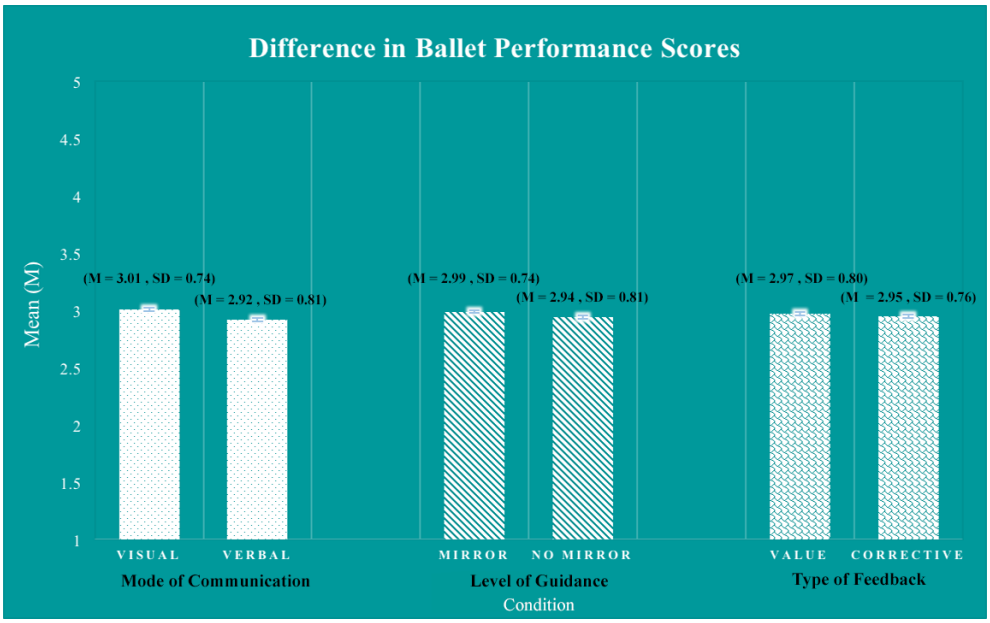

Figure 4.2 in mode of communication (visual and verbal), level of guidance Difference in post-test ballet technique scores for each of the conditions (mirror and non-mirror) and type of feedback (value and corrective). No significance was found in the mean differences for any condition.

Interviews revealed that 21 of 32 users thought that the verbal mode of communication was more helpful feedback than visual. Figure 4.3 shows the usefulness of the mode. Only 6 users preferred the combined visual and verbal. This portion is left for future studies due to the fact that it was not covered in this experiment.

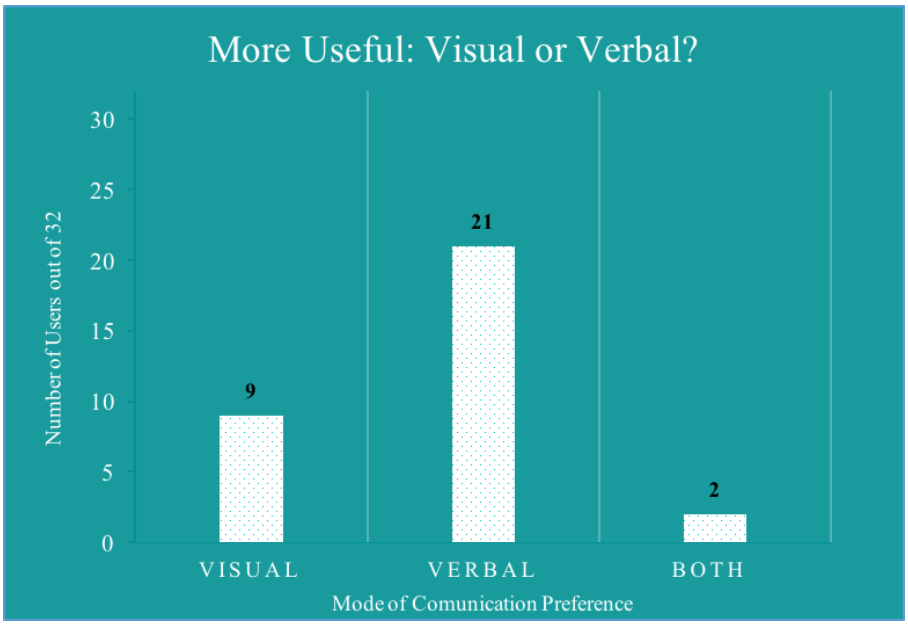

Figure 4.3 Graph of the usefulness between verbal, visual or combined modes. Verbal was the overarching preferred mode.

Overwhelmingly, 22 of 32 users preferred the mirror with the feedback; as can be seen on Figure 4.4, 7 users had mixed feelings about it and only 3 did not prefer a mirror along with the feedback.

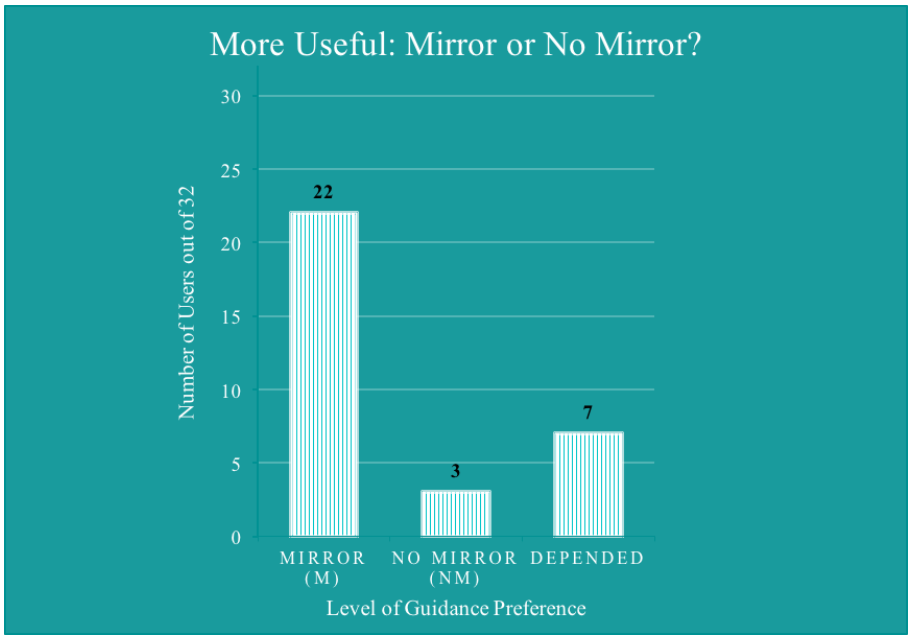

Figure 4.4 Contrary to what we had originally expected, there was no statistically significant mean difference in the scores for mirror (M = 2.99, SD = .744) and non-mirror (M = 2.94, SD = .810) conditions; t (766) = .904, p = .366. Users only performed .05 better in the mirror condition than the non-mirror mean score. Yet, overwhelmingly, 22 of 32 users preferred the mirror with the feedback.

4.5 Workload

Our third research question inquired if the overall workload elicited a significantly higher post-test workload than pre-test across all the conditions. The NASA-TLX workload was a self-reported rating from a survey that we administered directly to participants, while the previous scores were assigned from the teacher.

We plotted the pre-test and post-test NASA-TLX scores on a line graph to visualize the workload difference. Figure 4.5 represents the workload difference between the pre-test and post-tests. Overall, we can see that the difference in mean workload was not significant, only a range difference of 0.1 – 0.12 across all conditions. This implied that users did not experience a greater workload (mental

demand, physical demand, temporal demand, effort, or frustration) while viewing the feedback. This indicated that the feedback was not overwhelming in any one condition. The greatest disparity was found in the Verbal Non-Mirror Corrective condition where users experienced a lower workload in the post-test (M = 3.15, SD = .69) than the pre-test (M = 3.27, SD = .9), a difference of -.12. This implied that users found the feedback more satisfying. There was a possibility that although the overall condition had the greatest mean all of the conditions, users preferred to have the feedback as compared to the pre-test where no feedback was administered. There was also a possibility that users enjoyed not seeing themselves, or it was easier to process the feedback without the visual distraction of the mirror, or simply they did not need it:

> *User 2: "I felt more balanced without the mirror. I think probably you can concentrate more on balancing yourself if you don't have a mirror."*
>
> *User 6: "I think dancers rely on the mirror too much cause instead of seeing your own corrections, they're looking at other people and seeing what they are doing. When the mirror is there for your own benefit, not to kind of slack and not know certain things and look at other people."*
>
> *User 10: "I think I was more concentrated without the mirror there."*
>
> *User 27: "I'm not always looking at it [the mirror] unless I'm trying to fix something because for some I know the combination so I was just focusing on my muscles and my body."*
>
> *User 29: "I don't think that I actually made a correction based on what I saw in the mirror. There was too much going on and going wrong. There*

was information overload. I liked that it [the mirror] wasn't there. I'm thinking besides circuit training I've doing yoga in front of a mirror, but yoga movements are easier so it didn't motivate me or bother me when I would look in the mirror. It makes me feel worse about myself. It doesn't motivate me to do poorly, but it might make me feel ridiculous. Even though when I was taking ballet classes I was getting nice verbal comments from the teacher and the students, when I saw myself in the mirror, I felt embarrassed about it. I think I would be less embarrassed if I thought it was a machine"

User 32: "It depends how much you rely on the mirror. I personally thought it was easier to concentrate on the feedback was showing me and then just applying it myself."

There was a -.08 difference from the post-test to the pre-test mean in Verbal Mirror Corrective condition. This difference suggested that mirror with verbal corrective feedback may suggest a higher workload for users. This may be due to the increased information as verbal corrective statements when compared to the verbal value are longer. Therefore, it takes more time to process the feedback. Participant 11 expressed that she felt more rattled due to the notion that a human was evaluating her movements,

> *"If it [the feedback] was verbally, since I knew a teacher was watching me, I felt a little intimidated that someone was watching me."*

Participant 13 noted that she was distracted by the longer statements,

"Where it [the feedback] actually told you, I was more attuned to stopping and listening and then continuing rather than the shorter statements where it would say, 'Good' and I would keep on going."

The workload also increased for Visual Non-Mirror Corrective compared to other conditions, where corrective statements were also issued. All other differences across conditions were -.05 or less and were very close together to imply a great difference.

The lowest workload for the post-test condition was found in the Visual Mirror Value (M = 2.34, SD =.77). It suggests that users were most satisfied in this condition. This could be due to 8 of 32 users reporting that they were visual learners, as well as the simplistic nature of the feedback. Participants noted that it was easy to process, interpret and understand:

User 1: "It's [the emoji] quite directly in front of my face. It is easy to catch the information."

User 2: "Smiley meant that I was doing the movement correctly. Frowny face meant that I was doing the movement incorrectly. It was helpful for some movements."

User 4: "I know that it [the emoji] was trying to get at what I am doing well or doing poorly, I understood that."

User 30: "The visual feedback [was better] because it was harder to correct if I was hearing it than I seeing it."

Therefore, we can see that the overall observed workload for post-test did elicit a significantly higher workload compared to pre-test. This indicates that users did not experience feedback as overwhelming. Our hypothesis was confirmed.

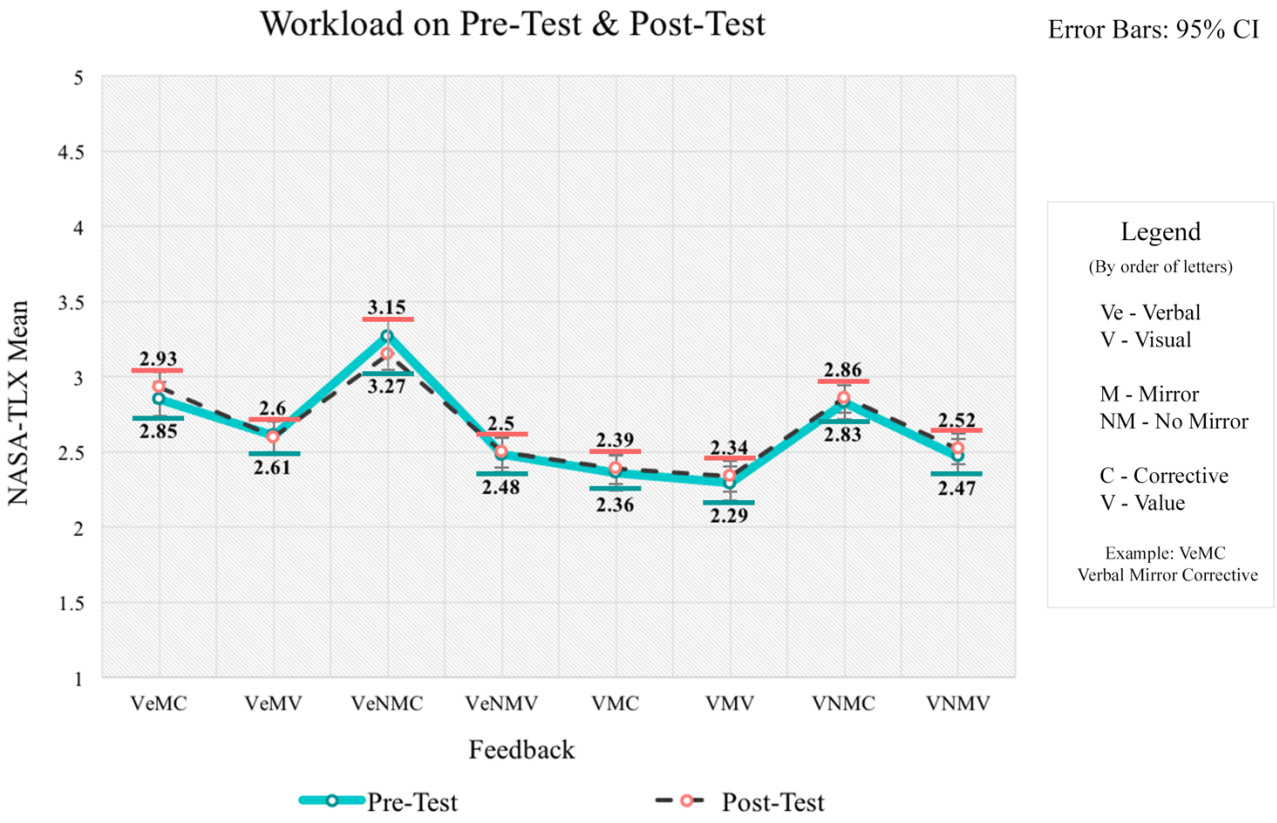

Figure 4.5 Workload difference between the pre-test and post-test NASA-TLX scores. Pre-test workload was with no feedback administered, while post-test workload was with feedback administered. The workload is similar therefore suggesting that the feedback did not overwhelm users in their mental demand, temporal demand, or frustration.

4.6 Difference Between Users With and Without Ballet Experience

We compared post-test technique scores of users with and without ballet experience to see which group had a larger impact from the feedback. We separated the data to include only post-test scores from beginners and experienced dancers. An independent-sample t-test was conducted to compare the ballet

technique scores without experience and with experience condition. There was a statistical difference in the scores without experience ($M = 2.86$, $SD = .717$) and with experience ($M = 3.45$, $SD = .763$) conditions; $t(766) = -11.014$, $p < .001$. This indicated that experienced dancers had higher scores than beginner dancers, which concluded that the feedback was particularly effective for this group. The overall design of the system was envisioned for users with dance experience. So this result is concurrent with the intention of the design. However, the results did not indicate that beginner-level students did not learn from the feedback as it was supported in the discussion. Beginner dancers need more guidance and most importantly, more time to capture the magnitude of information presented to them at once. It is vital to note once again that users were only taught the combinations for 1 min before they had two times to practice after which they were evaluated. The difference was only -.59. Figure 4.6 revealed a visual representation of the mean post-test scores in each of the feedback.

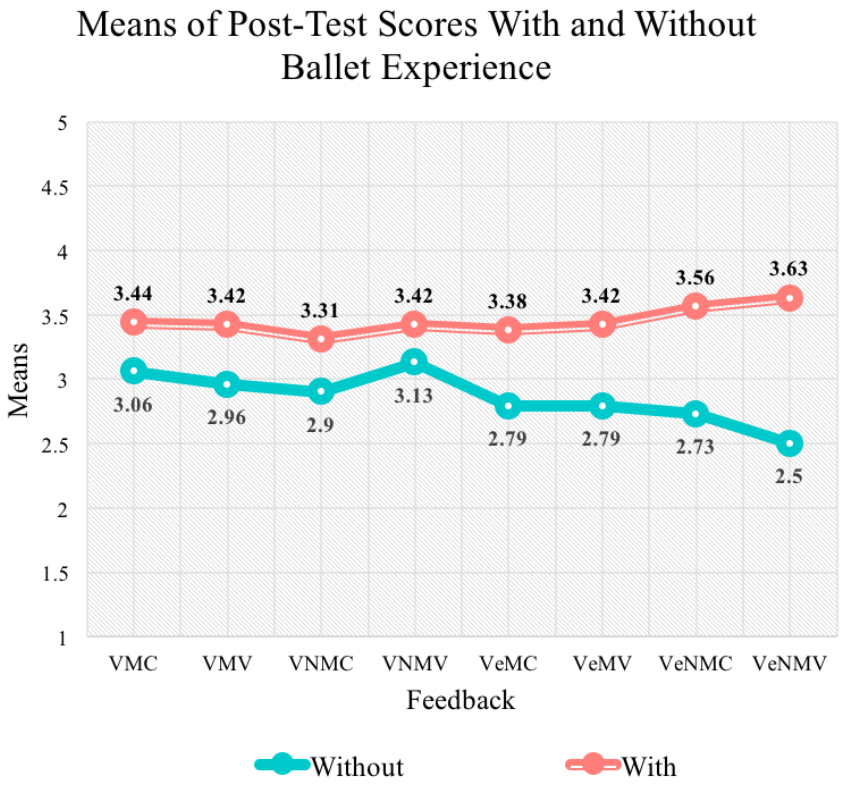

Figure 4.6 Means of post-test scores with and without ballet experience. Higher scores were seen by dancers with ballet experience, which validate the design for the intended user group. Two patterns emerged: The difference between scores was larger for verbal scores (average difference of -.795) than for visual scores (average difference of -.385) and the smallest difference occurred in the Visual Non-Mirror Visual condition. Findings will be examined in the discussion.

We saw two patterns emerge:

1. The difference between scores was larger for verbal scores (average difference of -.795) than for visual scores (average difference of -.385)
2. The smallest difference occurred in the Visual Non-Mirror Visual condition.

These patterns will be considered in the discussion.

The workload on users with and without ballet experience can be seen in Figure 4.7. Overall, users without ballet experience had a slightly higher workload compared to users with experience. However, these differences were minor with an average difference of -.234 and were not statistically significant. The biggest disparity was seen in Visual Mirror Corrective (-.55). This was due to the design of the joint overlay. Users with experience were able to infer its intended meaning, as it was designed for participants with some ballet experience. Users without ballet experience had a harder time interpreting its meaning, which resulted in a harder cognitive load. The workload on the Verbal Non-Mirror Value condition was slightly higher (-.38) for users without experience, most likely due to the inability to see a reflective image of their dancing, as well as the little guidance provided with value feedback. Interestingly, beginners had a lower workload while watching the video (Visual Non-Mirror Corrective) than users with experience. This indicated that beginners were more satisfied from the video. This could be due to the fact that it provided more guidance and support that beginners need at this stage of learning.

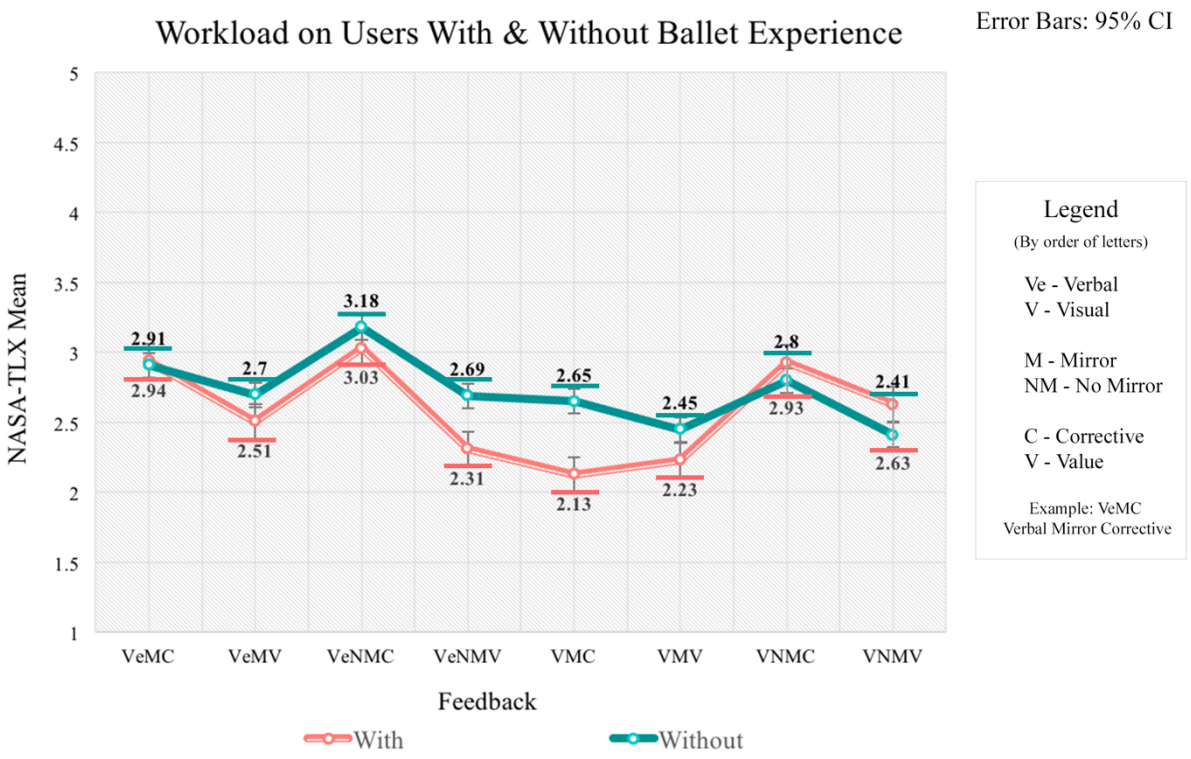

Figure 4.7 Workload difference between users with and without ballet experience. Overall, users without ballet experience had a slightly higher workload compared to users with experience. However, these differences were minor with an average difference of -.234 and were not statistically significant.

4.7 Results Conclusion

Our first research question inquired if the treatment had a significant effect on the ballet technique score. In order to see if the treatment was effective, an independent-sample t-test was conducted to compare ballet technique scores in pre-test and post-test conditions. There was a statistically significant difference in the scores for pre-test (M = 2.72, SD = .696) and post-test (M = 2.96, SD = .778) conditions; t (1534) = -6.518, $p < .001$. We did not imply that all treatments were equally effective due to lack of literature, but suggested that the overall combined feedback had an impact. The treatment was effective. Therefore, we determined

that the feedback had an impact on the ballet technique score and our hypothesis was confirmed.

The second research question inquired if there are feedback that impact the score more than others. We separated our feedback conditions and grouped our data according to mode of communication, type of feedback, and level of guidance with only post-test scores, omitting the pre-test scores. We did not run multiple t-tests on different experimental conditions (e.g., VMC vs. VMV and VMV vs. VMNC), which would require an ANOVA. Independent-sample t-tests were conducted to compare the score in the mode of communication (visual vs. verbal)/ level of guidance/type of feedback condition). There was no statistically significant difference in the scores for visual (M = 3.01, SD = .739) and verbal (M = 2.92, SD = .814) conditions; t (766) = 1.509, p = .132. There was no statistically significant difference in the scores for value (M = 2.97, SD = .801) and corrective (M = 2.95, SD = .755) conditions; t (766) = .394, p = .694. There was no statistically significant difference in the scores for mirror (M = 2.99, SD = .744) and non-mirror (M = 2.94, SD = .810) conditions; t (766) = .904, p = .366. There is a possibility that some conditions (e.g. mirror vs. non-mirror) did not impact the learning outcome. Our hypothesis was not confirmed. Future work should consider a bigger sample size to suggest if any difference in a separate condition has an impact.

Our third research question inquired if users perceived the feedback as overwhelming. The NASA-TLX workload was a self-reporting rating from a survey that we administered directly to participants, while the previous scores

were assigned from the teacher. Overall, we can see that the difference in mean workload was not significantly apart, only a range difference of 0.1 – 0.12 across all conditions. This implied that users did not experience a greater workload (mental demand, physical demand, temporal demand, effort or frustration) while viewing the feedback. This indicated that the feedback was not overwhelming in any one condition and that the feedback did not present a significant barrier in the workload. Our hypothesis was confirmed.

We also concluded from the feedback that expert dancers were impacted more greatly than beginner dancers, which supports the intended user design of the feedback. The feedback was more applicable to users with some experience, as it included ballet vocabulary, which, without any previous knowledge, would have been hard to decipher and understand.

CHAPTER FIVE: DISCUSSION

This section first discusses the results reported in the previous section. Subsequently, each of the conditions are individually explored. First, the verbal mode of communication analysis connected with value and corrective type of feedback is analyzed. Next, the visual mode of communication also combined with the value and corrective feedback is examined. The next section reports the level of guidance analysis. Additional parts of the preference of ballet learning style and the difference between beginner and expert user type are investigated. An inquiry on teacher and system preference is also observed. Finally, a set of design principles are provided on feedback.

5.1 Explanation of Outcomes

Results from the data analysis indicate that the combination of the eight feedback conditions demonstrate a statistical significance on the score. Furthermore, the treatment had an impact on the ballet technique score. These results can be explained further from the following observations in each of the conditions of mode of communication (visual and verbal), level of guidance (mirror and non-mirror), and type of feedback (value and corrective). The type of feedback is interlinked with the mode of communication. Verbal analysis will discuss and include the type of feedback as well as the visual analysis.

5.2 Mode of Communication: Visual or Verbal

Findings from the data analysis did not indicate whether visual or verbal feedback had a statistical difference on the performance scores. This may be

because the sample size was too small in order to determine a difference. However, visual scores were only slightly better than verbal scores, a difference of .09 in the mean. Since the mean did not have a sizable difference, we can get better insight if we examine the details in the user experience that will be outlined in the next paragraphs. Overall, the trend suggests that a combination of verbal and visual modes of communication create a promising harmony.

5.3 Verbal Feedback Discussion

Overall, users revealed that they preferred verbal modes of communication due to the specific nature of the feedback. Participants stated,

> User 4: "*Verbal was more specific. [The visual] you know something's wrong, but you don't know what it is*."
>
> *User 6: "You knew you were doing good or bad [with the visual], but then with the verbal one, it could tell you exactly what you needed to work on."*
>
> *User 7: "To me the verbal could be better cause with the visual it was like a frowny face, so I really didn't know what I was doing wrong, but I liked the faces because it was like 'Yeah come on what are you doing', but I liked it."*
>
> *User 10: "I guess with the smiley faces I didn't know what they're smiling or frowning at, so I was like, 'Is is my arms?', 'Is it my legs?', "Is it my feet?,' but with verbal, I got a little bit better sense of what was happening."*
>
> *User 13: "I liked the last one [it was verbal condition] where it says this*

is what you're doing wrong and this is how it should be corrected. I always feel l got more out of it when they actually tell me what I'm doing wrong. I think the verbal was better for me, but at the same time I liked the visual and the smiley faces. Verbal helps me more, but I liked the visual more."

User 14: "The verbal feedback was more helpful especially those where it said what I was doing wrong and what I could do to fix it. Looking at the smiley faces was okay, but it was not as good because I didn't know how to make it right since it didn't tell me what was wrong. I just had to keep trying different things until I got a smiley face."

User 15: "Verbal [was more helpful] because I knew exactly what I needed to fix."

User 16: "As soon as you can get more details than having it just say, 'You're doing good…bad…could use improvement' – this doesn't help at all. When I get more information about the position I should be in, that feedback helps."

User 18: "I liked the verbal feedback better. I think that the visual ones at the beginning were hard to tell what was going on and they're weren't specific. Whereas the verbal one was more specific and it felt that it was more personal."

User 21: "The specific verbal feedback because it tells you exactly what you should be doing."

User 25: "Verbal [was more helpful] because she tells you exactly what's

wrong like if it's your knees, or legs, or your toes and the other visual one – the smileys were confusing because it changed frequently like as it moves so you don't know which part was wrong."

User 28: "I think that the verbal feedback was way more helpful because I felt like my teacher was talking to me and yelling at me."

User 32: "Seeing it didn't make me think as much about it, but the verbal let me know exactly what I was doing wrong, not just something was wrong or something was right."

There were two types of verbal feedback presented to users, value and corrective as explained on page 13. Of the 22 users who preferred verbal feedback, the corrective feedback was the overwhelmingly preference. This was because it presented descriptive statements of what was wrong and most importantly, how to fix the error. Most of the frustrations indicate that they did not want a system that only specified what was incorrect, but rather they wanted to receive information that helped them understand what it was they needed to be working on; "I wouldn't say that the second time I did it, I got significantly better, but I can definitely see what it [the area feedback pointed out] needs to be improved." Going further, four users reported that verbal was less distracting than visual:

User 8: "I think I liked the verbal feedback because you can hear it as you are doing it, and you're not trying to read [the smileys] while you're dancing because it kind of throws off your concentration."

User 12: "The distraction was less with the verbal than it is with the visual. You can correct it while you are listening. The verbal feedback was

helpful because it pointed out which position you did wrong. You can pay more attention to it and change it."

User 19: "The visual feedback kind of distracted me. I think it was because of the angle at which the camera was. The angle of the projected image was different than looking at a mirror."

User 23: "It was easier to hear than concentrating on two different things – concentrating on what to do and the listening to what they are saying – putting that into what I am supposed to be doing."

On the other side, two users believed the opposite. While participant 11 believed that the verbal was more distracting and said,

"I felt that the verbal was taking my concentration someplace else. You had to direct your attention to the verbal feedback and listen to what it was saying."

Participant 1 noted that visual was a better fit for her because it was easier to catch the information since it was in front of her face,

"When people are nervous, it is quite difficult to catch the verbal information."

Participant 30 noted that she did not know the jargon in the statements,

"The visual feedback [was better] because I didn't know much of the terminology in the verbal statements so I was like, okay what do I do. It was harder to correct if I was hearing it than I saw it. You don't know what it applies to."

There is an importance of having terminology that is suitable for the intended user.

5.4 Summary on Verbal Feedback

Our second research question hypothesized that visual feedback would improve scores; however, scores improved roughly equally between visual (M = 3.01) and verbal feedback (M = 2.92). This could be because any mode of feedback was helpful. What is quantitatively true did not hold qualitatively. The user experience suggests that users preferred corrective verbal feedback due to its ability to specifically identify the error and suggest the next step for how to remedy it. This analysis suggests the following design implications about verbal feedback:

1. The errors should be explicitly identified and stated. The value statements of 'Excellent', 'Good', 'Could be better', and 'Needs improvement' are not sufficient due to their ambiguous nature. Corrective statements are more beneficial as they provide information of *what* the errors are and the next steps for how to remedy them. This is particularly relevant for beginning dancers who need more instruction with their corrections. A lack of support and remedy discontinues the loop of improvement.
2. Feedback needs to be given in a timely manner to the observation it addresses as to avoid distraction from the movement itself.

3. The system needs to adjust to beginning dancers that are not familiar with the ballet vocabulary and provide Layman language that they can understand with ease.

Next we will present the visual feedback in detail.

5.5 Visual Feedback

This section intends to outline the user experience of the three types of visual feedback, the Emojis, joint overlay, and video playback and the lessons of how the user interface can visually be improved for the future. Overall, users reported that while verbal was more helpful, they liked the visual feedback more because it became a source of motivation.

5.6 Emojis

The design of the visual value feedback of Emojis intended to depict the facial emotions they would experience from a ballet teacher. The Emojis did not intend to capture all the facial emotions a teacher would display due to the time-limit of the experiment, therefore only four were chosen to symbolize the movement: excellent, good, could be better and needs improvement. Users indicated that the Emojis motivated them to a certain extent and stated that,

> *User 3: "Even though it wasn't showing me exactly what to do, I still got encouraged when I saw the smiley. Next time I thought, I should push myself to get the smiley face shown.*
>
> *User 17: "I did like the smiley faces. They (Emojis) were simple to*

understand like small, medium and large. Like 'you need to get better, a lot better or this is terrible. It wasn't mentally demanding."

However, the information provided by the Emojis in the timing they were provided did not provide enough feedback,

User 9: "I felt that there was a bit of a delay so when I would do one movement, it would go smiley face and then immediately following a frowny face. I'm like, 'But which movement was that for.' That was the unclear part."

User 21: "Looking at it, I'm not sure what I'm supposed to improve like if it's a sad face, what do I do next? As you go on, you hope it gets better but you don't know how to fix it so it's kind of like trial and error."

This previous statement provides the backdrop for the essence of feedback as previously mentioned in the verbal analysis: that it needs to have explicit context-focused information and afford precise timing in order for it to be properly inferred. This highlights the similarity and importance of these two elements in the process of feedback.

5.7 Joint Overlay

The visual corrective feedback overlay of red dots that intended to outline the joints (elbows, hips, knees, and feet) where they displayed errors in their movement, did not resound well for the user experience. For example, if there were red dots on the knees, this indicated that the knees were turning in, or if there were dots on the elbows, this indicated that their elbows were dropped and

needed to be lifted. It is vital to note that users were not told what the feedback was prior to performing. This was an attempt to understand the current conceptual thinking of this kind of feedback. When asked the interpretation of the red dot's meaning. interestingly 13 of 32 users (40%) presumed that the red dot was the placement or position of where their body should be:

> *User 4: "I think they kind of mapped to my hands and my points [joints]. Since it was red I thought that, 'Okay if it is green I think I am doing it properly. If the points are showing in red, that position I should be correcting."*
>
> *User 6: "To me, it's either something I need to fix or I didn't know if there were just points on my thigh so then when I saw them on my arms, I lifted my elbows more and then with my knee, I tried to turn out more and stuff like that. I liked the dots the best because that was an exact visual of where exactly you needed [to place them]. Like I said with the verbal one that told you exactly [what to fix], this was a way to do both almost."*
>
> *User 7: "I think it was your foot placement and where you should have them instead of where they were, trying to match them."*
>
> *User 9: "They were guiding me in the right position of my limbs."*
>
> *User 10: "I thought that was where my arms were supposed to be so I could tell it was something to do with arms. I don't think I connected it with joints specifically, but I was like yea my arms are droopy and they're right."*

User 11: "My arms were supposed to be here, where the red dots were. They were guiding me in the right position of my limbs."

User 12: "If your position is accurate, the point is there to tell you where your position should be.

User 17: "Those were a little challenging. To me they represented where my legs were supposed to line up with."

User 19: "The smiley faces with the dots [were better combined], cause I'm pretty sure the dots were showing the position. It was a better visual feedback to show you exactly where you should be. Maybe putting on the side a list of the movements that go next like a head movement and then it would disappear would be nice."

User 30: "I liked the dots. Where you should be. Then they turned red."

6 of 32 (18.75%) users thought that the red dots were the visibility of the system and acknowledgement that their body was being tracked:

User 2: "I couldn't make out what they meant. I just thought it was tracking my movements."

User 9: "Initially, I thought it was just tracking my body but I wasn't sure it was feedback."

User 18: "At first, I thought [it was] whether or not the Kinect could detect my movements."

User 25: "I think they were just monitoring my movement. It came in later so I don't know if it was correcting me or monitoring."

User 26 believed that it was calibration,

"The red dots seemed like they were trying to calibrate me. It didn't appear that they were trying to correct me. They were trying to calibrate and see if my posture was correct or not. I didn't see it as a feedback."

Only 4 out of 32 users (12.5%) of users thought that that was the area to be fixed.:

"*User 24: ""They represented the position I wasn't supposed to be [doing incorrectly]. It would be helpful cause I know with Kinect games if the dots turned to green to show that you were doing it correctly or changed to yellow to be like you're almost there that would be better visual than having a red dot and then disappearing."*

User 31: "They [the dots] were the most helpful. But you don't know what you're doing wrong, as a very novice ballet dancer [I] sometimes don't know what the problem is so I want a little bit of more clarity."

User 4 even thought it was a programming error,

"I saw red dots while I was standing still but I didn't see any while I was moving. I

saw them on my heels. I honestly just thought it was a programming error."

Some users did not understand its meaning:

User 8:" I noticed one, but I didn't know what it meant. Now that I know it means, it makes sense. When I first saw it I thought, 'What does that mean?' Whereas when I saw the smiley faces, it was a clear, 'Oh yes'."

User 22: "I have no idea what the dots represented. If the dots were accompanied by voice, that would help."

User 23: "Didn't understand the dots. I would like it see the line of where the dots were connected to each other."

Users indicated that if the area changed colors from red to green, that would be a better indication that they corrected the area instead of just pointing it out.

5.8 Summary on Emoji and Overlay Feedback

This analysis suggests the following about visual value and corrective feedback:

1. Emojis as value feedback provide a sense of motivation for users; however, they did not help them correct their errors. The timing of the emoji also needs to be adjusted for quicker movements, such as jumping, and more static movements, such as tendue, degage and adagio. The speed of the combinations has implications on the timing of the feedback. More studies should be conducted in order to study timing.
2. Identifying the error was important, but remedying the error was just as important. Most of the users believed that the dot overlay indicated the position. Implications for design suggest that visually aiding users to the desired position was more helpful.

5.9 Video

The video presented users with two short back-to-back videos. The first video showed them the error they were doing with a label of 'X Wrong' in red. It was followed by another video showing them the correct way to fix that error with a label of a check mark and a 'Right' in green. Although the users preferred this feedback over the emoji and the red dots, a unique set of challenges arise for the video:

a) Importance of Timing

The timing of the video is crucial, as many users stated its inability to sync with the movements they were currently performing…"You played the video late. I already finished the movement" …" I liked the video, but it was not synchronized. I didn't expect a video there so before I could attune to it, it was over. You know if someone is performing, we would be observing them rather than anything else. I would have cognitive overload if I had to see the [right and wrong] and see here [the video] and also perform…" It was confusing. I was trying to focus more internally rather than having external feedback" …" I wasn't lined up with her. I was a little mixed up." This is an indication that the video as a feedback needs to have an immense level of precision in its timing if it is to be used. This timing is based on the type of movement users perform. From this study, it can be seen that with larger movements such as petit allegro or slower movements like adagio, the feedback was easier to understand, as the corrections were composed of a larger form. When feedback is allocated

to display smaller details, such as placement of the feet or hands, without proper annotation on the video, users were unable to determine for what exactly they were looking. However, implications arise due to the increased complexity of the display. Sometimes the more information increases, the harder it becomes for the user to capture, process and implement that given knowledge. The magnitude of information needs to be further assessed as it pertains to ballet systems.

b) Natural Instinct to Follow

Users instinctively followed the video when it began without noticing the labels on either video. This is due to the natural affordance video implies,

> *"The video was confusing, should I follow her or not? … "If you played the video at the same time when I started, I would have followed her. My first thought when seeing a video is to follow it automatically" … "That [video] was really odd because it just popped up, I mean what she was doing was exactly what I was doing, but then I was already it and the video popped up? Having a video in the beginning would be more useful and then in the middle I would have smileys or dots to kind of correct my positon."*

Video feedback will need to be redesigned to keep this mind. The already set affordance for video is difficult to avoid, as users are already accustomed to it. It is also important to note that the feedback for each user had a different combination. Therefore, there is a great possibility that some feedback works better for some movements than for others. For

some users, the combination combined with the feedback allowed a smooth transition, where for others it did not:

> *"When I had huge chunks of information coming in, I didn't know how to process it all. I didn't know if I should stop and then start again implementing that or if I should just continue doing it. I liked the detailed feedback, but how do you implement it? Do you start and stop and start over or do you just continue?"*

This statement notes the complexity that arises with video feedback. Follow-up studies will need to be conducted in order to address this issue.

c) Mechanism for Concentration

Users were easily distracted by the video because of the tendency to follow it:

> *"I got distracted watching her instead of doing my stuff. I was kind of trying to fix and then watch and it was too much at one time to concentrate…I would have to take a pause to watch it for a minute or two, and then practice."*

However, in a redesign, the feedback has promise due to the human quality of presence and possibility of comparison.

> *"Video was helpful out of the three because you can see how it's done. It would be nice to see you and the correct version side-by-side so you could be, 'Oh this is what I'm doing and this is how I should be doing it at the same time.'"*

This is a unique possibility that video allows.

d) Notion of Camera View

The Kinect camera, while positioned in front of a user, does not afford the same perception as looking at oneself in the mirror. This is due to the camera angle of the Kinect. While this is a technical implementation issue, it is worth noting that the nature of the camera that was not predicted beforehand. In order to replicate a mirror to mimic its capability, the camera angle needs to be accounted for.

e) Multiple Viewpoints of the Video

The videos were recorded from a specific angle, which was thought to give the best view of the correction to the user. For example, some corrections were shown from a side-angle versus the front-angle. All the participants performed the movements facing the front the entire time. However, users noted,

> *User 18 - "I thought it [video] was helpful to see someone do it correctly and then I would try and intimate them, I think it was hard because I only saw one side of them. I think for me it would be more helpful to see the front because that's how I would see myself in a mirror."*
>
> *User 31 - "Sometimes I know my biggest problem when I do ballet is that I have a tendency to bend forward and I'm not entirely straight that way so if the camera on the side that would help me more personally than front on."*

This statement also notes the multi-faceted complexity of a video. To support users thoroughly, a video needs to be shot from multiple angles to allow for user control and freedom as noted from Nielsen's 10 Usability Heuristics (Nielsen Norman Group, 2005).

5.10 Summary on Video

Overall, this presents the idea that video as feedback is not suitable for correcting errors in a movement due to its distributive nature, unless it accurately accounts for precise timing, an intuitive design that does not disrupt workflow, and multiple-shot viewpoints. The distraction overloads users' cognitive states, not allowing them to focus on the movements themselves. Achieving a natural flow in its playback would require an adequate-length clip, as well as the precise timing, both of which are difficult to control in scenarios where the state of the user's position in conjunction to the video is hard to detect. Users have the tendency to follow the video as it begins, rather than process what is shown on the screen. This implies that the timing is an important element to consider while showing videos. If timing is off, users become distracted and lose focus of the movement. This suggests that video may be more useful for learning the movements than for feedback *while* performing the combination. Kinect's camera-view is not as direct of a reflection as a mirror would be. In order to replicate a mirror to mimic its capability, the camera angle should be accounted for.

5.11 With and Without Ballet Experience

Results indicate that dancers with ballet experience displayed a higher impact from the feedback than users without ballet experience. However, results are inconclusive that beginners did not have an impact from the feedback because the feedback design was intended for experienced ballet dancers. This can be seen from Figure 4.6. We see two patterns emerge:

1. The difference between scores was larger for verbal scores (average difference of -.795) than for visual scores (average difference of -.385)

2. The smallest difference occurred in the Visual Non-Mirror Value condition.

A greater difference can be seen between verbal and visual scores due to the fact that verbal feedback includes ballet jargon, which may have been more difficult to comprehend for users without experience. Visual feedback did not have any ballet terminology. Users said:

> *User 3 – "I felt that as a beginner you would have more trouble. As you get more experience, it would be a lot easier."*
> *User 11 – "I didn't quite understand some of the lingo on the longer statements. If I had more knowledge, it would make sense."*
> *User 22 – "The verbal was more helpful, but some of the statements, I didn't really understand what they were saying. The language was unfamiliar. Possibly with more experience, this would be alleviated."*

The notion of beginner-versus-experienced dancers becomes of importance in the magnitude of feedback given. As beginner dancers, more guidance is needed with more explanation to capture the understanding that is needed in order to correct the given error. Participants said,

> *User 2: "Audio feedback was really helpful. 'Excellent' or 'Good' might be helpful for the advanced. For beginners, the longer statements with Layman language would be more helpful so that you could correct yourself. Once you're an expert, probably 'excellent' [would be better]."*
> *User 10: "I think that for a beginner it would be helpful to have both as they need more guidance. But as a more experienced dancer, I think it would be too distracting."*
> *User 16 – "I don't know. I liked it [verbal feedback], but I also felt that I wasn't completely catching and listening. I felt that I had to stop and catch what it was saying because I didn't quite understand some of them."*

There is also the vital factor of 1-min teaching time in the research design that may have impacted this difference. Beginning dancers need more than 1 min to learn each combination. Every aspect is new for them, from adjusting to turning out their feet, or developing the necessary coordination involved in executing the steps, to remembering the combination itself. There is already a heavy mental demand. Users said:

> *User 3 – "One of the steps needed more time for me to learn because it was totally difficult, and I am totally new to this kind of dancing. The one-*

minute gap I kind of struggling with. This was only for one or two movements."

User 5 – "The combinations – I may not have done those combinations before, I just wanted to make sure I was doing it right and like trying to think up here and made sure all the muscles moved the way you wanted."

The most interesting finding is that the smallest difference between scores for beginners is in the Visual Non-Mirror Value condition. We do not have enough data to find a statistically significant result if non-mirror impacted this difference or if it was the value condition. However, it may suggest that beginning users scored higher in the non-mirror condition due to the ability to concentrate and develop more of a sense of their kinesthetic awareness. This notion needs to be further explored in follow-up studies.

5.12 Summary on Visual and Verbal Mode of Communication

There is a similarity in the feedback from the viewpoint of visual and verbal modes of communication. From the analysis, we identify five design principles that should be carefully considered when designing technologically augmented mirrors for dance education –see Table 5.2.

Feedback needs to be specific in how to remedy the error.	Users prefer feedback to be specific, to not only convey the error, but also to provide relevant information regarding how the error should be corrected. One example would be using corrective

	feedback, but in a manner that *specifically* identifies the error; this could be best presented by visually circling the error and then guiding the dancer to the right position by displaying the position in which they should be instead.
Feedback needs to be descriptive.	Feedback needs be descriptive, but not as to distract the users from their current task. The magnitude and speed should be properly assessed and allow for user control of these variables.
Feedback needs to account for different user types.	User control needs to be allocated for a difference between beginner- and expert-mode to allow the ability to increase or decrease the guidance.
Feedback needs to allow multiple repetitions of feedback loops.	Notion of repetitions or trials for practice are needed to allow for improvement by showing feedback multiple times in a loop. Future research will determine how many repetitions of the feedback are needed.

Feedback needs to allow comparison views.	Seeing is believing. Users noted that comparisons set up side-by-side indicating to dancers what they did wrong and how it should be done, allows for a mental and visual cue of understanding the difference.

|Table 5.2 Design principles from verbal and visual mode of communication analysis.

Therefore, the possibility of best fit arises if we combine both the visual and the verbal feedback as one. Users also expressed this feasibility when asked follow-up questions and comments,

> *User 4: "I think that with the verbal, it was a lot easier with the mirror, that way you could adjust yourself and see yourself adjust."*
>
> *User 7: " The analysis showed that the right combination of the two complement each other as verbal feedback proved to be more useful while visual was more aesthetically pleasing."*
>
> *User 19: "The visual combined with the voice, that would also help you memorize what you're doing."*

This notion of combined feedback is expressed in the Figure 5.1. Follow-up studies should be conducted in order to determine the right balance between these two modes of communication, as this was not the focus of the current study.

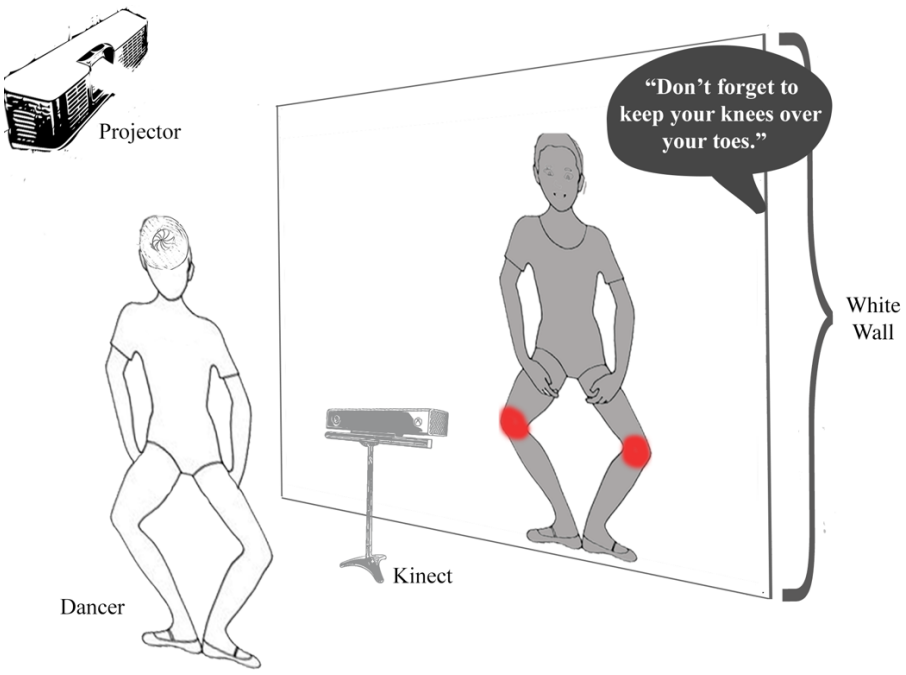

Figure 5.1 Combined visual and verbal feedback suggests promise for future design.

5.13 Level of Guidance: Mirror or Non-Mirror

Ballet as an art form and athletic "sport" is the only one to employ a mirror. The importance to detail is stringent as the codified set of movements and positions set every part of the body in an exact place.

Blackmer (1989) states that the mirror becomes a tool to foster a dancer's "third-eye". This notion describes the mental image of how others view the dancer. Participant 31 had an ice-skating background along with ballet and described the way ballet movements differ from ice-skating and the way the mirror benefits from the action,

> *"The movements are so isolated in ballet that seeing yourself is way better than being in the dark. In skating, we are kind of forced to be in the dark,*

but we have so fluid motions that it's harder to isolate particular things. I think a mirror is better in ballet."

This highlights the pivotal role the mirror plays in ballet. Users liked being self-aware of their movements:

User 2: "I would like to see myself because I can see where I am going wrong."

User 4: "It's almost easier when you can see yourself because I know that I don't turn my feet out, you can't really look at them without losing your balance. You can look at them without losing your balance."

User 7: "I kind of almost liked it when you could see yourself just so that way you could know your movements and you could actually see yourself doing it."

User 8: "I liked the mirror better cause you could see what you're doing wrong cause if you're just like staring at a wall or just a blank screen you're like 'I wonder how my hips are looking...I wonder if everything is aligned' You're just wondering how you're looking like overall. Whereas when you have the mirror you can see your mistakes and you might correct them before the teacher sees them to correct them."

User 12: "I prefer that there's a mirror in front of me. It is easier. I can focus on myself and adjust my body position."

User 22: "Mirror was more helpful. Just being able to see myself and knowing that okay my toes are not pointed I need to do that."

User 28: "I liked the mirror better because it's familiar."

The mirror also provided an extension for the user to solidify the mental image of the movement:

> *User 11: "I felt seeing myself was a better idea to practice because you had a mental image in your head of how the movement should look like and with the mirror, that was possible to see."*
>
> *User 14: "When I didn't have the mirror, I didn't know – in my head I could reposition myself but I didn't know what was right or if I looked better."*

Without the mirror, many dancers, particularly beginners, had a tendency to look down at their feet:

> *User 5: "When I didn't see myself, I kind of looked down at my feet to make sure I was doing it right. I wasn't paying attention to the feedback on the screen because I wasn't sure what I was doing wrong or right."*
>
> *User 9: "I didn't realize there was a smiley face feedback because there was not a mirror and so I was looking at myself, looking down which you're not supposed to do. I was looking at myself versus the screen. I think that the loss of the mirror does not make me look forward."*

The looking down could be because beginners were not used to the technique in ballet and were unsure of what they were executing. Certain feedback along with the mirror was poised to become a source of distraction. User 16 noted,

> *"Depends on the approach there, when you are seeing yourself and the information was going on another part, when you have the smiley feedback, it was too many things to pay attention [to]. I'm looking at me and trying to see myself, what I'm doing and I also need to focus my attention on the feedback."*

This indicates that the mirror with the Emojis becomes an overload of information. Participant 4 noted the possibility of having the mirror along with verbal feedback to help focus the dancer and apply the corrections,

> *"I think it was a lot of visual distraction when you have feedback and have to look at yourself at the same time so probably without the mirror. I think that with the verbal it was a lot easier with the mirror that way you adjust and see yourself adjust."*

Users also noted that that too much dependency on the mirror was not a good thing. Participant 32 noted,

> "I think dancers rely on the mirrors too much. I think it's good not to have it sometimes."

There were users who explained that the mirror made them self-conscious. This was especially true for beginners, as the movements were new and awkward for them:

> *User 23: "I liked the no mirror with the feedback just because I couldn't see myself."*
>
> *User 26: "I was more comfortable without the mirror. I was not worried about not seeing it. Without the mirror, as a student, it was bad because I was not able to track myself. But as a person, I felt less self-conscious. If you didn't have the mirror, just with the feedback, it would have been great."*

This expresses that for a particular type of user, especially geared for recreational dancers, having feedback would be enough without the mirror. Nonetheless, users expressed that the mirror became an essential tool if an individual wanted to see improvement:

> *User 24: "I personally don't like seeing myself in the mirror, but for learning I think it's better to have something you can reflect on."*
>
> *User 29: "...what you feel inside is not necessarily what is really going on so I know that it is important [to use the mirror] when you want to improve."*

However, users noted that they preferred the mirror because it was familiar. User 26 pointed out that,

"If you didn't have a mirror, just with the feedback would have been great because at least something is tracking your movements."

The notion of having a system give feedback as a concept is new in the dance world.

5.14 Ballet Learning Style

We also asked users what was their preferred learning style for ballet: visual, verbal, kinesthetic, or some combination of the three. It is interesting to note, as seen on Figure 5.2, that 8 of 32 (25%) dancers classified themselves as solely visually learners. However, 9 of 32 described themselves as a combination of all three learning styles. This study only includes visual and verbal modes of communication, so further research should look at a kinesthetic approach. This was omitted from the current study due to its complexity and a lack of time. This has implications for the design to study how to include haptic mode. This in turn, we believe, would provide a holistic user experience where learning would further increase.

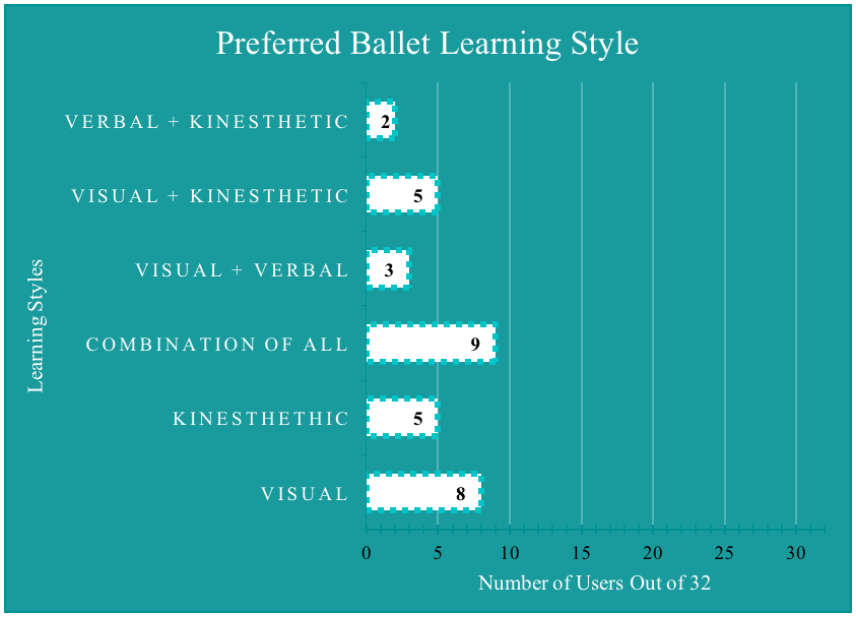

Figure 5.2 User self-reported classification of learning style. The majority either identified as visual learners or combinations of visual, verbal and kinesthetic. 8 of 32 (25%) dancers classified themselves as solely visually learners. However, 9 of 32 described themselves as a combination of all three learning styles. This study only included visual and verbal modes of communication, so further research should look at a kinesthetic approach. This was omitted from the current study due to its complexity and a lack of time. This has implications for the design to study how to include haptic mode. This in turn, we believe, would provide a holistic user experience where learning would further increase.

5.15 Summary of Level of Guidance

This analysis indicates that overall, users preferred to have a mirror. It became their safeguard and provided assurance to the dancer that what they were performing came out the way they mentally pictured it. However, along with the smiley feedback, it provides a level of distraction for dancers and some information overload. Users expressed that the mirror made them self-conscious, which is congruous with Radell, Adame, & Cole (2002). The possibility of user control in mirror preference may alleviate this issue and provide flexibility to those that want to use the mirror. Future research should apply a mode of

kinesthetic feedback, possibly through the use of haptics. In this way, learning would potentially increase and the user experience would be holistic.

5.16 System vs Teacher

In overview, Figure 5.3 presents the preference for the system versus the teacher. 16 users who had previous ballet experience were asked after the experiment if they preferred to have the system versus the feedback. Surprisingly, 7 preferred the system, 7 preferred a teacher and for 2, it depended on several factors. For a beta and experimental system, these results are promising. While the current tool in place is the mirror, which employs immediate feedback, it does not tell the dancer precisely what she is doing wrong:

> *User 5: "Even if you are looking at yourself, you can't tell what you are doing wrong most of the time."*
>
> *User 11: "I would learn faster and get to know my errors much earlier on."*
>
> *User 32: "It [the system] would be helpful because you're getting that feedback back. You're not just watching yourself, you're getting someone else's point of view."*

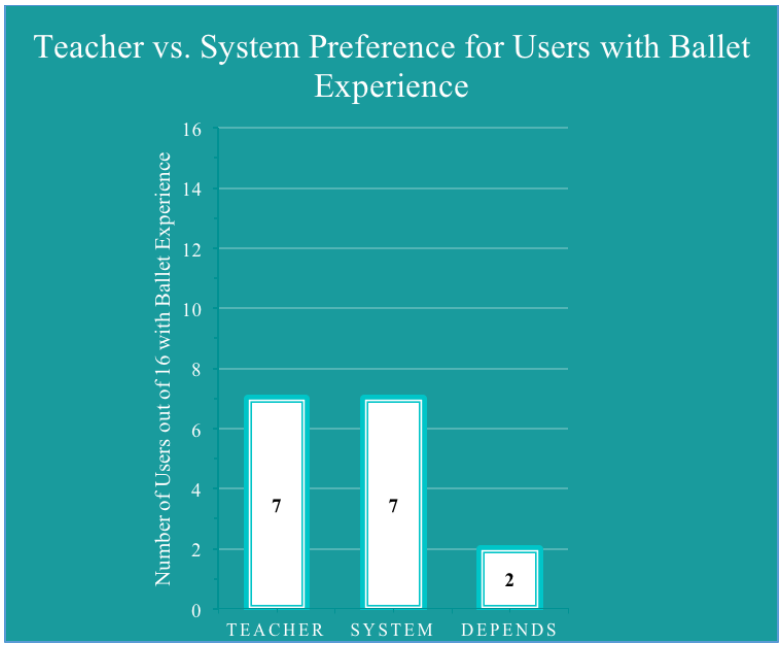

Figure 5.3 Sixteen users who had previous ballet experience were asked after the experiment if they preferred to have the system versus the feedback. Surprisingly, 7 preferred the system, 7 preferred a teacher and for 2, it depended on several factors. For a beta and experimental system, these results are promising.

One could say that this is why a teacher is and should be present. However, participants emphasized the notion that the focus was solely on them. They felt secure that the feedback they received was accurate:

> *User 8: "It could be helpful because when you are in a large classroom, it's hard to get the one-on-one because if they're correcting one student, they missed everyone else and their mistakes. Whereas when it's one-on-one, you're getting your individualized mistakes corrected."*
>
> *User 31: "I think it [the system] was better cause the focus was on me. In class you compare yourself to everyone else, but that's not good because they could be doing it wrong too. So I like this system. Someone who knows what is right or not is giving feedback."*

It costs an estimated $100,000 to train a ballerina (Abrams, 2015). Over a period of 15 years, more than $50,000 of that sum goes towards ballet education at a top-tier school (Abrams, 2015). Abrams (2015) also concludes that high training costs result in a lower diversity rate of dancers. Private lessons according to Diana (2014) cost anywhere from $40-$150 per hour as well as a studio rental fee of $15-$25. Teachers have busy schedules and often find that an empty studio can be hard to come by, especially to book dancers that cannot get out of school early. Leslie Hench of Ribbon Mill Ballet in Carlisle, PA, stated that to get the maximum benefit of private lessons, you should "Go as much as possible…Having privates every day is beneficial, but it's expensive. If you can't go every day, try to schedule private lessons at least once a week" (Diana, 2014). A system such as this shows promise to combine the expert opinions of multiple teachers into one whole comprised system. In this way it can become available to students that cannot afford high-level training. It reduces the time needed to travel for an exceptional teacher. The benefits are mutual. Students are able to get high-quality training while teachers can provide their expertise to a market of the world. Participant 13 who is, apart from a student, also a teacher, stated that this type of tool shows promise for teachers:

> *"As a teacher myself, I can't go around to every student myself and tell them what they're doing wrong. So if I had that system, I feel like it would be great for my students and I would love that as a student myself."*

The system can also become a tool for motivation and as a way for shy students to alleviate the personal pressure required for dance:

User 10: "It would definitely be helpful over break when I don't have class so for example right now, the last 4 years I've gone 3-4 weeks in winter or summer break without dance unless I specifically go and find it. Over the last 4 years, it would have been really helpful to have something like this during breaks to keep up with dance and not just be forced to self-motivate myself to practice tendues and stuff like that."

User 15: "Some people don't like being called out. This way they can go home and work on it so that would be great."

The system also poses as a reminder management system as Participant 23 puts it,

"You can go home and practice instead of being like, 'Oh what did they say [teachers during class] and then guessing and doing the wrong thing. Sometimes when they physical place you into a position, it doesn't stick."

Some users liked the idea of having both the teacher and the system as an interplay of balance. When not receiving the necessary attention from the human source (the teacher), one can rely on the system instead. On the other hand, users also expressed the drawbacks of systems that heighten levels of intimidation, lack of trust, and shortage of experience. Participant 8 noted that the system would be more intimidating because,

"You don't know the person, whereas you know the teacher, you have a relationship with them previously build but having someone else you don't know come in and watch you, it's really intimidating. "

Can ballet experience be captured in a system? This becomes an important notion for the design of ballet systems as Participant 27 disclosed,

> *"I think there is something you can get from a teacher that you can't get from a system, no matter how sophisticated it is, but I think that this would be a really helpful tool on days that you were not in classes with someone and with those bigger classes where you don't get the individualized attention. Maybe you could come up to your teacher and say, 'I was working with the system over the week and it was saying I was doing this wrong, could you maybe help me with that…and could you also pay attention to that in class'."*

The ability to store a teacher's experience in a knowledge expository could not only help students and allow teachers to help more students at a time, but also allow for the ability to hand down teaching styles, practices, and techniques from generation to generation. This is a fundamental concept that current pedagogical practices do not necessarily capture. Sims & Erwin (2012) note that all the dance teachers in institutions of higher education capture their expertise and knowledge through previous teachers. This indicates that currently, the only way to pass down prestigious knowledge is from teacher-to-teacher. Teaching methods have remained largely unchanged in ballet history. Ballet is not a dying art form, but how can it keep up with and remain relevant in a rapidly changing and high-tech society? How can we better equip training to take ballet into the 22nd century? There is a challenge of acceptance of new technologies among those in the dance world. Legacy bias becomes a concern because often, the acceptance is dependent on ballet teachers.

While realizing that ballet is a multi-faceted and complex theory of knowledge that is composed of not only a level of feedback, but also a level of kinesthetic feedback, it is also a highly codified set of positions, movements and phrases (Radell, 2003). The connection between ballet and technology is not new. Since the advent of videos, dance teachers have implemented this technology for a multitude of elements such as recording, analyzing, and saving dance choreographies (Birringer, 2002). According to Leijen, Admiraal, Wildschut, & Simons (2008), the influence of technology on dance is still in its initial phases. Dance was a late adopter of technology compared to other fields (Calvert, Wilke, Ryman, & Fox, 2005). The authors state that there is unwillingness from dancers and choreographers to adopt such a medium that will stand between them and the live kinesthetic experience. Also, the commercial success of such technological tools is sparse and unable to develop in the market. E-learning environments in dance are not new (Garland, & Naugle, 1997; Popat, 2001; 2002; Mandile, 2004; Kavakli, Bakogianni, Damianakis, Lamou, & Tsatsos, 2004; Leijen, Admiraal, Wildschut, & Simons, 2008; Damianakis, Tsadima, & Tsatsos, 2009). However, the advent of using real-time feedback for ballet training to the extent of our knowledge has not been implemented. This study implies the trend of and the feasibility for real-time feedback in distance ballet learning.

5.17 Implications of Results of Outcomes

The main implication of the results extends to the connotation of real-time feedback from a distance.

The following design principles were established on feedback with references tied to Nielsen's Ten Usability Heuristics for User Interface Design (Nielsen Norman Group, 2005).

Feedback for ballet systems needs to be *MuscAt* because like the Muscat family of grapes, it consists of many interconnected layers:

1. Multimodal,

   A system's feedback needs to incorporate the human sense of visual, auditory and in the future, kinesthetic forms of communication in order for a holistic view of assessment. Combining both visual and verbal modes where, for example, the correction would be provided verbally and then the remedy presented visually, would allow for a more immersive learning experience.

2. under user control,

   One size does not fit all. The capability for allowing users to control the various variables of feedback is important. Controlling access, such as specifying the magnitude of feedback, level of guidance (mirror or non-mirror) and user level (beginner, intermediate and expert) will grant users the flexibility of their preference for a custom learning experience.

3. specific,

   Evaluation needs to be specific yet descriptive. Users need explicit information about not only the correction itself, but also relevant explanation and steps to approach resolving the error.

4. continuous,

   Users would like to see feedback presented in a continuous repetitive manner without breaks in between. Similarly, like to a mirror, a repeated stream of information would be presented that would not break their concentration and the flow of thoughts on the movement at hand.

5. And have precise timing.

   The timing at which feedback is given is a vital element. Users may miss the response if it is not presented at an adequate measure. Depending on the speed of the movement, the timing may change. Movements that change height and direction frequently, such as petit allegro and pirouette, would require slower timing as users either jump up and down or turn. They would not be able to catch the feedback if it is presented while they are in motion. More repetitive and static movements such as tendue, adagio, degage, plié, frappe and battement tendue will have different measures of timing.

Examining the details further, the notion of implementing both visual and verbal modes into one system becomes a point of interest. The level of guidance suggests that user control is preferred. Other suggestions include presenting a focal point for users in the non-mirror condition to allow for a prime focus. Musicality is a crucial element in ballet. It is the ability to understand music on a technical level and allow that knowledge to transfer in the movements and dance “inside the music, as opposed to floating on top of it” (Lewis, 2010). A gamified option could

also open a possibility to quantify the feedback as a score shown to users. This would be an indication of the performance. In this way, users would gain a clear mark of their process. The potential to demonstrate the next movement as in the game Dance Dance Revolution (DDR) would allow for more guidance as a secondary feedback mechanism.

CHAPTER SIX: CONCLUSION

In this study, we render feedback elements composed of the mode of communication (visual and verbal), type of feedback (value and corrective) and level of guidance (mirror and non-mirror) used in the long-established ballet teaching to real-time Kinect-based feedback. The traditional ballet learning environment is transformed to an e-feedback setting where dancers are given evaluations on their ballet technique from a distance (remote site). We use a technologically simulated mirror with value and corrective augmentations to present feedback to dancers. We extend the knowledge of previous research on visual and verbal feedback and the effect of mirrors on dancers' techniques, where we propose a bottom-up approach to designing feedback for Kinect-based systems for ballet. We access learning by a domain expert to ensure the system has had an impact.

Our findings indicate that feedback has a significant effect on the dancers' ballet technique scores and learning. Dancers performed better with the feedback than without it. While we found no significant score difference between visual and verbal feedback, most users preferred verbal feedback due to its ability to not only present the specificity of the error itself, but also provide steps to remedy the correction. However, most users also expressed that they were visual learners. Therefore, we concluded that the best possible fit was to combine the visual and verbal feedback as one, to provide for a better learning experience. Furthermore, no score difference was found between value and corrective feedback, which

suggests that users performed well with both. We found that Emojis motivated users to a certain extent, while the joint overlay provided potential guidance to lead dancers to the correct position. The video feedback was not found to be sufficient because users were distracted from their movements while watching the video clips. The video's affordance implied that what was shown on the video should be followed and not seen as evaluation of their own work. Interestingly, users performed well with the technologically augmented mirror, as well with a non-mirror which contradicts Radell & Adame (2003). However, this needs to be verified with actual mirrors in future studies. We also discovered that the experienced dancers were more impacted by the feedback than beginners. However, various factors, such the use ballet jargon, 1-min teaching time, and the magnitude of feedback given, contribute to this difference. Further focus needs to be given to this difference in future studies.

Ballet training is expensive, and requires thousands of dollars, and currently the only way to access expertise is face-to face. But what happens for students who cannot gain access to a great teacher? What about teachers that want to help as many students as possible? With this study design, we are able to demonstrate that remote teaching is possible. The possibilities are exciting. These tools allow the access of first-class teachers to students around the world and disregard the limitation of physical boundaries between teachers and dancers. We demonstrate the feasibility of remote teaching and the potential path for how this type of tool could be aligned for teachers to help students. The novelty of approach is an

indication that technology-added verbal/visual indirect contact with students still allows for an improvement in the performance. Exploring the different concepts of human-machine interface, specifically for ballet dancers, and adapting to current and future generations that are accustomed to the advent of digital technology shows a promise of potential advantage over the current ways of teaching.

Limitations

Due to this study's time, participants in the sample are 32 IUPUI undergraduate and graduate students. With a larger sample, we could use more detailed statistical techniques to draw statistically significant and generalized results. Ideally, all the students should have substantial ballet training; however, there was no access to these types of participants for the timespan of the study. In the future, collaborating with a ballet school would provide more access to a specified user type. The ability for a longitudinal study within this study's timeframe was not possible. The experimental environment was not in a ballet studio. With a more traditional environment in place, the system can become more embedded. The current study also does not use a control group.

Future Research

This study is envisioned as an initial step in a multiphase process consisting of:

1. Conducting an ethnographic approach to analyze the current practices and patterns of offline teaching; refine MuscAt to allow for a more nuanced distance relationship, down to the investigation of how the size and length of screen, as well as the scale of the image effect the performance.
2. Elements of count and rhythm measurement including a musical accompaniment as well as exploring the implementation of the haptic mode of communication as a kinesthetic way of learning to provide a holistic user experience.
3. Opening a path toward "virtual teacher," based on Machine Learning algorithms and data collected by converting traditional ballet teaching to e-teaching.

Future research should also speculate whether the video feedback might be used in a different way to increase its effectiveness, e.g. with a time delay or instant replay feature that would not distract the dancer in the middle of the combination. Studies with a larger sample should to be conducted to find a trend.

Summary

This exploratory study addressed the beginning steps in designing effective feedback in Kinect-based systems for ballet. We explored how receiving feedback (elements of the visual and verbal modes of communication, value and corrective types of feedback, and mirror and non-mirror level of guidance) compared to not receiving any feedback. The treatment demonstrated a statistically significant difference in the improvement of the ballet technique

scores. Although no particular conditions were found to have a statistically significant difference on the performance, this tool shows promise. The study suggests that remote teaching in ballet is possible. Refining and improving this system would move ballet from "dance the oldest art, is today but a young science" to the needs of 21st century.

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APPENDICES

Appendix A: Instruments

We will be using:

1. Microsoft Kinect One
2. BenQ MW853UST+ 3D WXGA - 720p DLP Projector - 3200 ANSI lumens projector
3. Canon VIXIA HF R62 camera
4. Windows computer to house the C# application
5. MacBook Pro laptop for Skype connection
6. iPhone 6s as a timer and audio recorder

Appendix B: Questionnaires

Demographic Pre-Test Questionnaire

1. What is your age? _____

2. Have you danced ballet before? (Circle) Yes or No

   If yes, go to question 3. If no, go to question 4.

3. How long have you been dancing ballet (months/years)? _____

4. Have you had experience with Kinect before? (Circle) Yes or No

Post-Task Questionnaire

Please answer the questions to the best of your ability.

1. Mental Demand

How mentally demanding was performing the movements?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

How mentally demanding was the feedback?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

2. Physical Demand

How physically demanding was performing the movements?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

3. Temporal Demand

How hurried or rushed was performing the movements?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

How hurried or rushed was the feedback?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

4. Performance

How hard did you have to work to accomplish your level of performance?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

5. Frustration

How insecure, discouraged, irritated, stressed and annoyed were you while performing the movements?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

How insecure, discouraged, irritated, stressed and annoyed were you while viewing the feedback?

1 Easy (Not very demanding)	2	3 Neutral (neither easy nor demanding)	4	5 Very demanding

Interview Questions (The Dancer's Toolkit, 2012)

1. Is the system helpful in assessing your mistakes? Why or why not?

2. Does the reflection of my technique get better or worse when I see myself in the mirror?

3. How much time do I spend correcting errors vs. noticing other things about myself (hair, make-up, leotard) or other dancers? E.g. 10%, 25%, 50% of the time.

4. If I am having a good class- I'm on my leg, I feel centered and balanced- does that change if I stop looking in the mirror?

5. When the mirror is "taken away" or covered, do I panic? Do I lose my center and my bearings? If so, how long does it take for me to get re-oriented?

Follow up questions include, "Can you tell me more...is there something else.."

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Thesis: Usability Evaluation of Kinect-based System for Ballet

Research Interests

- User-centered design
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- User-experience design, as well as an interest in understanding the social and psychological implications of technological design.

Experience

Research Assistant, Department of Human-Centered Computing, Indiana School of Informatics and Computing, Indianapolis, IN, August 2014 – Present

- Conduct research in the area of embodied interaction and feedback modalities for Kinect-based systems for ballet