

Designing for Ballet Classes: Identifying and Mitigating Communication Challenges Between Dancers and Teachers

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ABSTRACT

Dancer-teacher communication in a ballet class can be challenging: ballet is one of the most complex forms of movements, and learning happens through multi-faceted interactions with studio tools (mirror, barre, and floor) and the teacher. We conducted an interview-based qualitative study with seven ballet teachers and six dancers followed by an open-coded analysis to explore the communication challenges that arise while teaching and learning in the ballet studio. We identified key communication issues, including adapting to multi-level dancer expertise, transmitting and realigning development goals, providing personalized corrections and feedback, maintaining the state of flow, and communicating how to properly use tools in the environment. We discuss design implications for crafting technological interventions aimed at mitigating these communication challenges.

Author Keywords

Ballet education; Ballet technology; Feedback; Challenges

CSS Concepts

• Human-centered computing~User studies

INTRODUCTION

Learning motor skills (such as kicking a ball) can be effectively enhanced by providing “augmented feedback”, *i.e.*, feedback that gives external information offered by a trainer or a display about the performance of a skill [61]. “Augmented feedback” has great potential to improve the way in which we teach and learn complex motor skills, because it provides additional information that users are not receiving from their muscles [28] [65].

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Ballet, in particular, is a good scenario in which augmented feedback can facilitate skill acquisition [71]: it is considered one of the most complex, exacting, and demanding types of movement due to its codified technique (a set of movements, positions, and esthetics that comprise all other dance movement [29]). The studio used for ballet training, however, typically includes a floor, a barre, and a mirror; besides lights and music players, there is not much technology involved (see Figure 1).

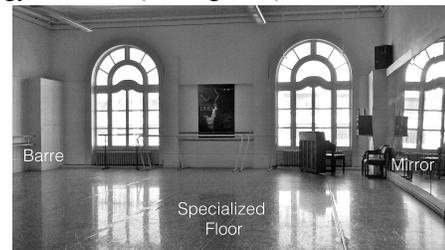


Figure 1. Typical dance studio composed of three elements: mirror, barre, and specialized floor.

In recent years there have been attempts to design dance technologies, for example by creating augmented mirrors (*e.g.*, [44]) or by providing dancers with sensors or virtual-reality devices (*e.g.*, [11]). We acknowledge the importance of these works in bridging technology and dance. There is, however, a lack of field-based knowledge on how teachers provide feedback during a ballet class, and on the typical challenges that dancers and ballet teachers encounter while learning and teaching ballet [67]. In this paper, we report findings from semi-structured interviews with seven experienced ballet teachers and six pre-professional dancers at a large dance conservatory in Maryland, United States. Our analysis revealed a list of communication challenges that should be addressed when designing technology for dance. Contributions of this work are three-fold. First, we present a set of challenges that should be considered when designing ballet systems that focus on the learning that occurs in the interaction with other people and tools in the environment [16]. Second, we highlight temporal stages of feedback and the impact for the design of feedback in ballet systems. Third, we present design considerations in attempt to alleviate the proposed communication challenges.

RELATED WORK

Feedback and Learning in Ballet

Feedback in dance class serves three objectives: 1) “as information to direct error correction, 2) as reinforcement, and 3) as motivation” [6, p. 28]. The effective design of the feedback delivery, however, has been controversial due to the notion that dance learning practices lack standardization [9]. Moreover, training to this day follows a classical authoritarian, “old school” model where a teacher exerts all the power. As Johnston [32] states, “Traditional authoritarian ballet pedagogy is high on structure and expectations, but low on teacher warmth and responsiveness. Conformity and obedience of the student are valued over open communication. Discussion between teacher and student, or amongst students, is actively discouraged. Within this teaching style, students are expected to be seen and not heard; not to speak unless spoken to. Students should think, but dare not speak, lest they be seen as troublesome or disruptive” (p. 3). This model of training has persisted because ballet exists for over 200-years, therefore, it tends to be “highly tradition-bound, with many teachers simply repeating what their teachers did” [1, p. 166]. Most ballet technique books and manuals emphasize the technical elements of incorrect and correct execution of steps over a holistic learning process [75]. Despite recent efforts to promote student agency in ballet, especially in academia, the field struggles to surpass its authoritarian pedagogic history [74]. The influence of dance technology is still in its initial phases because it is a late adopter of technology compared to other fields [64]. Not surprisingly, there have been recent attempts to induce technology into the ballet studio using tools such as Kinect [44]; motion capture [26]; virtual reality [27]; augmented reality mirror [1]; mixed reality [73], and a combination of these [11][59], where the focus has been in the comparison of incorrect to correct movements than extending the understanding of the learning process. Furthermore, these technologies are often too expensive and invasive to implement in the studio. To design feedback tools that are effective, we need to understand how teachers and dancers currently learn in the space. There is a lack of work that translates the experiences of the current practices of teachers and dancers into requirements for digital technology. This research extends on prior work that focused on exploring the design of visual and verbal feedback for Kinect-based experiences as well as remote learning through a controlled study [66] [67]. There is now an emphasis toward researching the “experience of learning and performing, and how things are happening in dance classrooms” and the role of new technology in changing dancers’ practices [50].

Dance Notation

Existing attempts to induce technology into the dance studio comes in two formats: traditional and contemporary. While traditional technologies such as mirrors have changed the environment of the class, they have existed for hundreds of years and they have remained constant and unchanged, plagued with limitations. Contemporary technologies are those that can be found in the informational era, with the advent of advanced tools.

Although the use of technology for dance has been explored since the 1980s, the main focus has been on how to support dance notation (*e.g.*, Labanotation [8] to improve the choreography of dance performances [23], or to provide aesthetic visualizations for performances (*e.g.*, Palazzi & Shaw [52]).

Virtual Reality

Other work has started exploring how technology (including virtual reality (VR), augmented reality (AR), and full-body interaction) can be used to support dancers. For example, Eaves *et al.* [17] “report the effects of real-time VR feedback on motor skills and explored the ability to focus the learner to key features of a to-be-learned action” (p. 3). OutsideMe by Yan [73] is 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 [26], which combined mixed reality and motion-capture. Kyan *et al.* [36] designed a system incorporating VR and a Microsoft Kinect in a CAVE environment that provides concurrent feedback. The use of virtual reality, however, implies wearing special glasses or devices, which is cumbersome for dancers: dancing with something strapped to their heads can also prevent dancers from performing all of the movements in the way they intended. Furthermore, these devices may isolate people from one another [38], limiting the social component of learning that happens in classes.

Kinect-Based Interactions

Similarly, Kinect-based experiences have also been introduced for teaching dance. For example, Marquardt *et al.* [44] designed a Super Mirror that uses a Kinect to combine “the functionality of studio mirrors and prescriptive images to provide the user with instructional feedback in real-time” (p. 1619). The feedback that dancers receive from the system was limited to visual cues, which did not present information sufficient for dancers [68]. Anderson *et al.* [1] compared YouMove, a whole-body, interactive, augmented reality mirror system, to traditional video-based instruction methods. The YouMove system is immovable from its current location in a lab and thus, cannot be implemented in

a traditional studio. It provides feedback that does not incorporate feedback mechanisms and language used by teachers in traditional ballet classes, so knowledge would not transfer and apply to dancers.

Feedback and Open Challenges for Dance Technologies

The feedback that dancers receive from the ballet instructor should be designed as to correspond to the authentic nature of the activity, in this case, ballet. “Authentic activities” refer to the definition as provided by the influential work of Brown, Collins, & Duguid [7] on situated cognition, “the ordinary practices of the culture” (p. 34). Designing feedback for a system should include not only visual mode of communication but include other forms such as verbal, which is essential for the improvement of dancers’ performance [6] [34]. It is important to also consider the type of dancer, whether they are a novice or an expert as that has an effect on the mode of communication and type of feedback they need to perform their best [67]. The gap in the design of the systems mentioned above do not consider designing for the support of *both* dancers and teachers. Thus, designing effective technological interventions for the benefit of *both* dancers and teachers remains an open challenge.

METHOD

Our primary interest was to gather insights related to ballet teachers’ and dancers’ experience in communicating during ballet classes to be able to design tools for both, so we designed an exploratory qualitative study based on semi-structured interviews and in-situ observations. We conducted 55 hours of observation over the period of two months (May-June) (see Figure 2). Prior to conducting the interviews, researchers drafted an interview protocol with several iterations that included the use of open-ended/closed-ended questions with an emphasis on the participants’ challenges with communication and the role of the current tools in the studio. More specifically, for teachers, we were interested in the challenges of teaching, the teachers’ relationship with students, and their decision-making process when providing feedback. Questions included, *What is your decision-making process when it comes to feedback? How do you choose what to focus on? Or in other words, how do you decide what to tell a student when you see multiple things wrong? How does the mirror affect dancer’s technique in class? Please give me an example.* For dancers, we wanted to learn about the challenges of being a dancer, the way they receive feedback from teachers, and performance tracking. Questions included, *What makes you discouraged during class? How does the presence of the teacher in the room influence your progress? Do you always understand what the teacher is trying to explain to you when they correct you? How do you know when you are improving? How do you best learn about*

your performance in technique class? How do you feel you use the barre? Do teachers comment on your use of the barre? Give me an example. For both participants, we wanted to know the impact of the current tools in the studio (mirror and barre) on their learning/teaching. We devised design probes to stimulate thoughts around speculative technological tools in studio using augmented mirrors, mocap cameras, sensors, and drones. Questions included, *How would this kind of tool change your practices and your role? When would occur if the technology breaks down or becomes overused? Imagine if there were drones flying around the studio studying the dancer’s placement. Do you think it would be distracting?*



Figure 2. In-situ observation at a large dance conservatory.

Study Population

Seven ballet teachers and six pre-professional dancers from the age range of 14 and above, dancers ($M = 17$, $SD = 1.73$) and teachers ($M = 59$, $SD = 4.94$) were recruited via a summer intensive course at City Dance School and Conservatory, a large dance conservatory in Maryland. One researcher conducted the fourteen interviews (60 minutes, on average) via phone or video conference calls.

Data Analysis

Following the interviews, researchers transcribed the dialogue to allow for a deeper analysis of the data. Authors then analyzed the data using an iterative and inductive approach [13]. A round of initial open-coding gave prominence to nine themes related to challenges in learning/teaching, feedback, and tool environment use. Through the process of iterative memoing and axial coding, we identified three challenges for dancers and two for teachers, respectively, with four challenges as commonalities for both types of participants.

CHALLENGES BETWEEN DANCERS AND TEACHERS

This section discusses the emergent themes about the open educational challenges faced by teachers and dancers. First, we will define the type of feedback provided in a ballet class. Second, we present insights into the temporal stages of feedback that teachers adopt. Third, we highlight the challenges that teachers face during the teaching process. Then, we introduce the learning challenges that dancers encounter. Lastly, we unpack their shared challenges.

The ballet teacher provides in class feedback through three different communication modes [21]: visual, verbal, and

kinesthetic: (1) Visual Mode – Feedback that includes full demonstration of the movement, facial expressions such as a frown or an approving smile, hand movements, etc.; (2) Verbal Mode - Feedback through the use of verbal/auditory statements and/or expressions such as “Super!”, “Drop your elbow just a little”, as well as vocalizations such as “DUM de de, Dum de de, dum DAAAH d’dum.”; and, (3) Kinesthetic mode - feedback that enables the student to physically feel corrections that includes moving the spine into the proper shape for a *cambré* or adjusting the line of the leg in arabesque. Feedback is categorized into three types: 1) Value – any word/phrase that reveals a judgement, 2) Corrective – focuses on an error and/or mitigates that error, or 3) Neutral – descriptive and factual feedback.

Temporal Feedback

Learning ballet is a social activity where a shared group of dancers develop a community of practice. A key component is “legitimate peripheral participation” [24, p. 23]. When dancers first enter the class, learners are “relatively peripheral in the activities of a community, and as they become more experience and adept, their participation becomes more central” [24, p. 23]. Learners increase their participation via “cognitive apprenticeship” [12] where they engage in 1) modeling, where the master performs the task that learners can observe, 2) coaching/scaffolding, where the master observes and facilitates the learner doing the task, and fading. The master (coach) first teaches the apprentice by making their tacit knowledge explicit and revealing the tools of the trade. For example, a ballet teacher takes a dancer under their wing and gives them one-on-one mentoring. During this training process, corrective feedback from the teacher is critical to bring the performance of the apprentice closer to that of the master. The final step empowers students by allowing them to take on the activity independently, which means the master slowly fades out their support to enable the dancer to develop independently as well as have the ability to self-correct to continue learning.

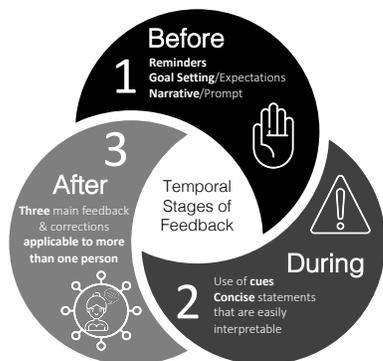


Figure 3. Process of generating feedback in ballet class is structured in three temporal stages: (1) Before, (2) During, and (3) After.

Through open-coding, we identified three temporal stages of generating feedback from teacher to a dancer as shown in Figure 3. In order to enhance dance feedback, we need to unpack and mimic these teacher’s feedback stages.

Designing feedback that matches this process (Figure 3) will help ensure that the tool is effective for both teachers and dancers alike. Many dance systems, however, have only considered feedback strategies classified at two points in time: either during the task execution (concurrent or real-time feedback [62]) or after it (terminal feedback [62]). Our observations highlighted the importance of providing reminders before a movement as well as the use of cues or “concise phrases, usually one or two words” [35, p. 299] during a movement. Following Figure 3, before a combination, teachers provide reminders and anticipate what mistakes dancers will want to do beforehand to watch out for pitfalls:

“There are certain things as an experienced teacher and as a dancer, that I know that the body tends to wanna do on certain exercises. So, what I try and do is get ahead of that and remind them already that okay, you’re gonna what to do this, don’t.” [T1]

One teacher mentions the importance of providing a narrative and a prompt as a way to direct attention and learning through the use of imagery and analogies: *“I think that I just found over the years that sometimes to give a student a prompt, it kind of gives them license to go, let me think about it from this approach. I think that I use a lot of analogies or imagery to help students try to find the way I like the way a combination to be executed. If you give them something to think about and help provide a narrative, I think that the narrative and the musicality and the technique make for a better learning process. I think they all help and inform one another.” [T2]*

Two teachers mentioned that they set the goals and expectations as a way to prime the dancer for that specific movement:

“It’s goal setting within the combination. So, before you begin, you say, my expectation is that you will give me a huge jump here, and I will see the foot clear the floor and you will feel like you are flying through space.” [T3]

“When I’m giving an exercise, I always say to my students, “This is what I’m looking for within this exercise.” [T5]

During a combination, the teacher will provide concise statements in the form of verbal cues that trigger an immediate picture of what it is they need to correct:

“I try and make them concise, not to make a long drawn out explanation, just like I say, booty down, that’s like a short, concise, you know exactly what I am saying. You figure out those words to say that are short, and people can immediately picture what you are talking about as quickly as possible.” [T1]

It is vital to incorporate words and phrases that indicate to the dancer promptly what they need to fix:

“These are the kinds of cues and feedback that I give, which helps them just cut to the chase and do the movement. Like heels down, knees over the toes, diaphragm lifted, go to your lower center on those turns when your arms are up, you don’t go up, you go down to go up...” [T3]

After a combination, teachers provide expounded advice and feedback that is applicable to more than one dancer:

“There is something that many people are doing and then I usually go to that thing first so that it will help more people...I’ve tried to spend the most time on things that most people are doing wrong.” [T1]

Due to the infinite errors a teacher sees during a combination, the feedback they remember to give becomes the three things they deem vital to be corrected:

“It just becomes the three main things that stick out in my head, and then I’ll approach those.” [T2]

Challenges for Teachers

Teachers face two main challenges while teaching, including trying to teach students who have differing dance competency, skills, and practice and providing useful and timely feedback to these students (Figure 4).

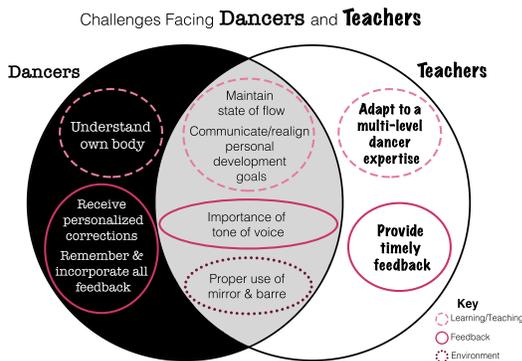


Figure 4. Challenges facing dancers and teachers in learning/teaching, feedback and from the environment.

Adapt to a multi-level dance expertise

All skill-based activities have a distinction between the levels of expertise – whether one is a beginner or an expert. The dance community has multitudinous approaches of defining and grouping dancers in ballet classes. The problem is that there is no global standard in how studios decide who fits in the particular level. Every dance school has its own method, one that is often based on their business model, and not the learning needs of dancers. In the end, more often than not, students are clumped together with differing experience levels all in the same room. In this scenario, teachers face the additional challenge of figuring out to whom in the class they teach. One teacher explained:

“Within a class of twenty, you might have five different levels, you might have beginner, you might have beginner-intermediate, intermediate and all up to advanced. So, there comes the challenge of whom do you teach to, the most advanced kids or go down the middle so that’s the challenge – so that everybody would begin to benefit.” [T6]

Often, classes become too geared into one particular dancer: *“Sometimes I walk into the class and I feel like, okay, this class is geared towards that student, the one student who can get it and then the rest can’t get it. For me, that’s really horrible to fill, where I’m gearing a class to one kid and one kid only and the others are trying to keep up.” [T5]*

The challenge is that the teacher has a limited time in the class and has difficulties in how to best manage their time. Most classes are 90 minutes long [60], where the structure follows combinations at the barre, center, and across the floor. Furthermore, even if a class has multiple levels (so more experienced students could potentially help novices), the continued authoritarian style of teaching that still exists today prohibits dancers from asking questions and places an emphasis on student disengagement:

“It’s very simple to teach when you sit like a big distance in between you and students. I’m asking you not to talk, you know, don’t ask questions, just do it. And frighten them. It is simple actually [because the] majority [of teachers], 85, 90 percent of teachers [are] doing this.” [T4]

Provide timely feedback

One teacher mentioned the challenge of providing corrections to every student in room at their time of need:

“I think it’s very challenging at times to be able to really correct and everybody in the room and give the attention they need, whether they are advanced or beginner students. Having the time to do that with every one of them and not miss something can be a challenge.” [T2]

One dance instructor often teaches dozens or more students at a time. Due to this, the feedback the instructor can provide is limited [22], and not always delivered at the proper time [34]. One teacher mentioned that besides timely feedback, it is important not to provide *too* much feedback:

“The shorter and the simpler the feedback, the more the succinct and the more the message addresses the gist of the problem, the better effect you have. Sometimes you can expound on it, like I am, but expounding in a classroom doesn’t necessarily work. Some teachers find that they can lose students when they give too much feedback. The child just stops thinking and you’ve already lost them.” [T3]

Prior work reports that one of the main issues is how to give sufficient feedback to enhance performance without overloading the student with too much information [71]. The biggest constraint on learning is cognitive load and the constriction of how much data can be processed at once [14].

This means that when novices are overwhelmed with new content, the representation of the relational structure is most likely to deteriorate. Our brain's limited capability to induce new information also means that, when learners are exposed to too much new information, they have fewer opportunities to generate new interferences, make connections to prior knowledge, and develop new mental schemata [30]. In ballet, this means that learners will take a longer time to learn new information (but time in an art form is a precious commodity). Research, however, has shown that learning can benefit from using cues to direct attention to relevant content (e.g., Lorch [42]; Mautone & Mayer [45]), allowing learners to pace their training in order allow sufficient processing time (e.g., Lusk *et al.* [43]; Mayer & Chandler [47]). One teacher emphasized the notion of cues as one of her training principles:

"I believe in verbal cues because I think that you can get to the point while they're moving, and their brain goes yeah, yeah, I remember that without a long explanation." [T3]

Mayer [46] describes a cognitive theory for multimedia learning that combines three themes in cognitive science – dual channels, limited capacity, and active processing – to enable meaningful learning to occur. The theory begins with four channels, (for details, see [14], Fig. 7, p. 103): 1) Multimedia presentation, 2) Sensory memory, 3) Working memory, and 4) Long-term memory. Mayer goes through each of the channels to describe the processes that occur. Learning begins with the multimedia presentation and sensory layer when a selection of relevant words and pictures from the presented input are stored in the respective visual/pictorial or auditory/verbal channel. Learners then organize this information into a coherent mental representation in a pictorial and verbal mode. These two modes are hereafter combined with prior knowledge and existing mental representations. This then results in a meaningful learning outcome that allows the visual and verbal material to be stored in long-term memory. This means that, when designing feedback for ballet systems, it is possible to more effectively balance the information load by providing both modes of communication (*i.e.*, by including visual/pictorial and auditory/verbal elements) [14].

Challenges for Dancers

The following themes were established for dancers: Understand own body; Receive personalized corrections and attention from engaged teachers; and Remember and incorporate all feedback (Figure 4).

Understand own body

Three dancers talked about the struggle of understanding how to incorporate corrections to your body and engage certain muscles:

"So sometimes I can't, even though I feel like I'm engaging my muscles and in the correct position, sometimes I'm not always correctly there." [D2]

The teacher's physicality has an effect on learner's ability to provide feedback as they see it from their point of view: *"I remember last year I was coaching with this one lady and she is very different style dancer than me, I am tall, and she is very tiny, and she was giving me corrections for shorter dancers. It didn't help me, and I had to change coaches because of that. One correction may work for someone, but it may not work for someone else."* [D5]

One teacher validated this challenge for dancers stating that a tool that helps dancers understand and track their body changes would facilitate their development: *"One of the biggest battles to help the dancer understand their own body, how they absorb technique, how they feel things, and how they are gonna actualize their talent through their body. Kids, while they grow, go through all these different things, they go through adolescence, their hormones change, they gain weight, they lose weight, when they found out how to turn their legs out, they stop gripping the quads, they use different muscles. This is a constant molding and changing of the body."* [T3]

Receive personalized corrections and attention from engaged teachers

According to all the dancers, a bad technique class means that a) teachers did not provide enough personalized corrections and b) they were disengaged and not paying attention:

"I had some teachers that gave exercises but there weren't a lot of corrections. I just didn't feel like I got a lot out of the end of it, it's kind of a more distant approach. I found that less helpful. Anyone needs a teacher always on them and always correcting is because a lot of times you don't realize that you're stinking and that you're engaging certain muscles." [D1]

"I think [what makes me discouraged in class is] when teachers are not paying attention and it makes me wonder why I am here when they don't even care." [D5]

Three dancers noted that providing declarative knowledge was not enough: there is a need for procedural knowledge. Corrective feedback such as, "lift your leg higher" does not provide dancers with enough information about how to correct their position or movement. All dancers need feedback that notifies the learner on *how* to correct the error [4] [63]:

"It's probably just when a teacher tells you to "put your leg higher", like how, I've always been asking that question a lot and sometimes it just doesn't help you, you can push and grip your muscles as hard as you can." [D1]

"I had my hip up the side when I was doing a developpe to the side and walked up to me and had me redo the developpe."

She was like holding my leg and she's helped me figure out how to put my hip down. And that was really monumental in fixing that.” [D2]

“So, I think to have someone like physically show me like this is what you need to be doing. If someone says you need to be more over your leg, you might think you're over your leg, but you won't know until they physically put you there or tell you how to.” [D4]

Ballet training is almost solely taught as a declarative skill, meaning that the vocabulary is taught, but not explained [60]. Explaining procedural knowledge in dance is difficult as Luke Kalich, a leading voice in dance education, writes, “The adjustment from training (learning the movement vocabulary) to education (learning the **how**, why, and history/aesthetic of the movement vocabulary) can be daunting to both student and teacher” [32, p. 227].

We observed a discrepancy between the frequency of feedback that dancers want, and what teachers perceive that they need. One teacher stated that there are two main teaching styles, 1) Curriculum-based, and 2) Feedback-based. The curriculum-based sets the structure of the class. You give and follow that curriculum and you can deviate as all good teachers. However, when teachers can't go forward, they go back, they compartmentalize, they take a piece of it and break it down, they give them something related, but the curriculum itself, the movement itself ignites the brain and the system [69]:

“That is why a good curriculum does work because it will excite the child and the ignite the learning and the thinking” [T3]

T3 further explained that even if some students think that the teacher is at fault if he/she doesn't give enough feedback, that is part of their pedagogical approach:

“Even though sometimes you don't need to give a lot of feedback, they don't realize that, they just want to hear, it's their learning style. You don't want them to learn exclusively through talking.” [T3]

The underlying idea is that a combination of learning through movement and feedback through verbal cues provides a dancer enough guidance that the movement takes over the body:

“...they get it and you think wow, look you just got it, you just did it and you didn't even know you did it.” [T3]

A sub-challenge that arises with the generation of feedback and attention is the notion of “favoritism” in ballet class [48]. Notably, those who are naturally gifted and talented will receive the most attention from the teacher. It happens often and dancers are left discouraged, helpless, and do not see the point in going to a particular teacher's class:

“It can be very frustrating because I tend to take it personally because I'm trying to work hard enough or do well enough

to get their attention. Sometimes it gets so in your head that it is detrimental.” [D1]

“I'm over here working my butt off, but they don't really care.” [D3]

“Sometimes is better to not take their class and do a different class just so you can keep getting feedback from the teachers that are giving you.” [D5]

Remember and incorporate all feedback

Five dancers reported that they experienced difficulties in remembering feedback they received in technique class as they were overwhelmed to integrate it as it was delivered:

“When they overwhelm me, I make the executive decision to focus on one correction because I feel like that's the best thing for me. Then I do that, and I try to remember what the other corrections are for the future which I end up forgetting.” [D2]

Two dancers mentioned the importance of writing down corrections:

“I always have like this big fat notebook that I have been keeping since 2012 and 2013. But after every class I write down all my corrections. No one's going to remember everything. I think that can be helpful to just like look over every day or if you're just feeling like you want to like get in touch with all of your bad habits and just focus on your technique and everything.” [D1]

Shared Themes Between Dancers and Teachers

Common challenges exist for both dancers and teachers: Maintain state of flow; Communicate/realign personal development goals; Importance of the tone of voice; and Proper use of mirror and barre.

Maintain state of flow

Two dancers mentioned that staying focused in class was one of their biggest hurdles, while two teachers mentioned that keeping the focus of the class was difficult:

“The most difficult thing for me is staying focused during the class time because I get distracted easily. As soon as I get out of that mentality, I feel this is not a good class. I feel when I stay focused it's a good class.” [D4]

A state of flow occurs when the performer achieves a focused and optimal connection to the performance, where their personal abilities equal the needed challenges [31]. The performer becomes in complete tune with the task presented in front of he/she. According to Jackson & Marsh, concurrent and unambiguous feedback is vital to induce flow [31].

Communicate/realign personal development goals

One dancer and one teacher mentioned that it is difficult to communicate and grasp personal development goals, respectively:

“Sometimes what makes it even harder is when like obviously the teacher doesn't know what you're thinking in your head and the goals you have for the class. So, I think

that sometimes that kind of plays into the discouraging part.” [D3]

“It’s important to establish a personal connection with the student and learn more about their aims for the year, what do they want to accomplish and how I can help them get there. In a class of twenty dancers, that can be a challenge.” [T2]

To support the communication of personal goals, designers could consider a private messaging system within a platform for the entire ballet class.

Importance of the tone of voice

We identified four quotes from dancers and teachers that denote the effect of a teacher’s tone of voice on students’ performance. One dancer noted that a negative atmosphere is created that:

“inhibits your progress.” [D1]

Two dancers mentioned that the teacher’s tone of voice has the ability to dissipate one’s concentration and put you out of the moment:

“If [teacher A] yells at you as if you are beginning the turn, for me, [it] doesn’t work that way because my body gets shocked and then I’m not able to contain myself in the position, I flail around” [D2]

One of the most experienced teachers also expressed that the tone of one’s voice has an effect on students’ learning:

“It [has] taken me exactly 10 years to figure it out how to keep them [students] focused and quiet at the same time giving them full freedom. It’s the tone of your voice. When you’re teaching, you have to be quiet, because many quiet people become sensitive to the noise. Remember not to scream.” [T4]

Silence is also an important factor in student’s ability to perform. Dance is best learned within a relational and experiential approach [70]. In contrast to other subjects where “learning is perceived as a process of transference of cognitive knowledge, in the case of dance, practice is the core of learning as transference of both cognitive and bodily knowledge and skills, where knowledge becomes stored in the body” (p. 8). This means that, in order to understand how to do a ballet movement, dancers have to establish a mind-body connection through repetition. This requires intensive concentration. Ballet is a non-verbal discipline as one teacher says:

“The problem is if you do too much talking inside of an art form that’s really dance, it’s movement, then you take away from the child’s own ability to experience and really what you want them to do is learn from movement.” [T3]

Often, ballet is also a collective art form. This entails that learning is not normally accomplished in isolation, but among a shared group of dancers in a community of practice. Prior work in education emphasizes how the tone of the voice

communicates an extra message to the learner: as Fanselow [19] states, “It’s not *what* he said, it’s *how* he said it” (p. 23). The genesis of this statement goes back to the authoritarian style of teaching where commanding indicates that the teacher has power [3]. This points to the need to redefine dialogue in the dance space, by highlighting the importance on using a soft tone of voice that sends a message of trust, respect, and caring [3]. One teacher noted that the environment of the ballet class is changing, but most teachers often do not know how to effectively respond and react to it: *“There was a hierarchy. There was a ballet teacher who you what to do and you don’t ask any questions. Today, you can’t do that anymore. It doesn’t work.”* [T5]

Proper use of mirror and barre

We identified seven quotes for proper mirror use from teachers and six quotes from dancers. Communicating barre use yielded seven quotes from teachers and six quotes from dancers. When we consider the use of the mirror, there is a proper balance that needs to happen and that dancers learn over time. It requires discipline and technique not to become lost in the mirror. While the mirror is useful for identifying minutia, all the teachers agreed that dancers rely heavily on the mirror when their focus should instead be on internal movement. One teacher spoke about how the mirror takes away the student’s natural propensity and visual targeting, meaning the use of spotting and the eyes. Teachers need to instill learners from early on the proper way to use the head because the biggest difference between someone who is amateur to someone who’s a professional, is the use of the head and eyes:

“I think the students rely too much on what they see per their form rather than the movement quality. The mirror acts as a perceptual motor, it absolutely takes away a student’s ability, a student’s natural propensity and visual targeting, unless you tell them not to do that.” [T3]

“I get really upset with kids and stop looking in the mirror so much. You need to feel what you need to feel. Dance is really internal. So sometimes it gets very external, instead of internal. The mirror is a liar. You may think that looks great, but in reality, not really. You need to feel it, don’t look in the mirror. There are so many times that I wish I was able to take a mirror off the table.” [T5]

Some dancers acknowledged that they are aware that they should not be looking at the mirror all the time and that the mirror does not define the picture of one’s dancing; however, they point out that the mirror is always there, so it becomes difficult not to overindulge:

“I think that’s really challenging is to be able to see it in a objective way and to not get emotionally involved in it like just thinking about, okay, well how can I fix it?” [D1]

"I normally look at flaws, what I am doing wrong. I feel it's really hard to dance with a mirror because it's so different from what actually is. When you see a video of yourself it looks totally different from, I thought it was." [D5]

"There are some days when you look at the mirror and you feel everything is wrong and it's awful after that and you cannot come out of it. I over-analyze in the mirror and becomes unhealthy." [D6]

Fourteen quotes were identified for improper barre use. All the teachers noted that they spend a lot of time in class addressing hand placement and gripping, whereas dancers acknowledged their awareness of gripping:

"I think a lot of them are gripping the barre or not only gripping, also just having their hand not in the proper place that is supposed to be. A lot of the gripping comes from where they have their hands on the barre, you see. Dancers don't automatically know that; they were not taught that at the beginning." [T1]

"I'm gripping a lot like when the whites of your knuckles come out. I grab onto it for dear life a lot. It does tend to be a problem when you get focused on something." [D1]

These findings are crucial for the design of learning spaces and technologies because, as we mentioned, a typical dance studio includes three elements: specialized flooring, a barre (a stationary handrail attached to the wall of the studio) and a mirror. This form has largely remained the same for centuries with exception of the dance surface: dancers spent centuries dancing on wood floors until they evolved to sprung floors in the early 1970s [41]. Mirrors, in particular, have been part of ballet studios since the eighteenth century, although historically the genesis has not been clearly documented [15]. Ballet dancers have commonly trained in front of mirrors for the past 200 years due to the nature of ballet's traditional and codified form of dance that establish a high value on line and positions [56]. The mirror is visual form of feedback that becomes central to a dancer's ballet education due to their ability to present the dancer with a reflective and external image of their performance. Prior work has documented the mixed effects of mirrors on ballet dancers' performance quality [54][58]. The mirror is used as guide for dancers to see how they will be seen from the audience as well as providing constant feedback about the dancer's body and their performance during training [51][72]. Dance instructors have recently expressed doubts about the utility of mirrors in terms of location, body image, satisfaction, technique, retention, attentional, and kinesthetic awareness concerns [20][24][26][28]. Using the mirror to self-correct is not seen as the best guide [49]. Often, dancers lack the ability to *effectively* use the mirror in what is described as the "dancer-mirror feedback loop", where dancers lose the knowledge gained from the mirror immediately upon correcting themselves due to the inability

to remember the kinesthetic sensation when they saw the error [18]. According to Radell, when dancers utilize the mirror extensively in their training, they do not develop proprioception or the understanding of where their body is in a space, which ultimately hinders the development of their kinesthetic sensibilities, thus affecting their potential performance skills [56].

DESIGN IMPLICATIONS

The challenges that we listed in Figure 4 and discussed through this paper provide specific examples of areas that could greatly benefit from technological intervention in support of dance teaching and learning. Thus, they can be used as general guidelines when designing dance technologies that effectively improve the teacher and dancer experience in ballet studios. In this section, we focus on two examples that illustrate how dance technologies can stem from the communication challenges that we identified in this paper: video-tracking systems, and augmented mirrors.

Video tracking

An overarching theme that emerged through our study is the need to support the gradual transition from the traditional form of learning (that follows authoritarian methods) towards a space that encourages the creation of a productive dialogue between dancers and teachers and that fosters critical reflection. The skills of self-regulation and reflection are becoming more and more important in dance education today [39][53]. To support the challenges of adapting to a multi-level dancer expertise, supporting dancer's development goals, paying attention to tone of voice, providing timely, personalized feedback, incorporating all corrections, and understanding your own body, designers of dance educational technologies could incorporate four video cameras in studios (as exemplified in Figure 5) to be able to capture and quantify the data that dancers and teachers are emitting in class using video-tracking tools such as OpenPose [10] or Wmch [35].



Figure 5. Implementation of video cameras

Video technology provide a powerful tool when it comes to detailed movement forms such as ballet [40]. This kind of design provides dancers the ability to make effective decisions based on smart video data solutions with the potential to change the learning and feedback experience. The potential of implementing video analysis is twofold: (1)

it can provide personalized feedback to the dancer, including videos that they may be able to review offline after class for the ability to self-assess [40] and, (2) it may transform the way a dancer's performance is evaluated as well as the teacher's, [2]. Using video analysis tools, we could, for example, visualize the progress of dancer as shown in Figure 6 with specific reference to technical components such as turnout. Teachers can review this progress and determine how to structure the class to match the given expertise level. Furthermore, this approach can provide the needed information to classify dancers into adequate levels of ballet experience. To combat proper barre use and avoid gripping, designers can incorporate tracking mechanisms to count the number of times dancers grab the barre. As with many uses of technology, there are potential unintended consequences that may be associated with the inclusion of video analysis tools in ballet classes. If there is focus solely on quantitative measures, this technological intervention may exacerbate the pursuit of perfectionism in a dance form already concentrated on finite movements. Future work should further investigate how designers can visualize information and provide feedback to dancers and teachers that provides a data-driven layer to performance evaluation but does not demotivate dancers by shifting all the attention on a performance score. One approach could be to concentrate on a holistic improvement with the use of both quantitative and qualitative data (self-reports and evaluation on artistry) that aligns to dancers' and teachers' goals for the year. For example, we suggest the use of a visualization that depicts a pictorial representation of how close a dancer is to reaching their goal. Furthermore, when probed if teachers would like cameras in their classes, four teachers gave rise to the need and importance of presenting evidence to dancers to prove that they made a specific mistake. Video tracking can therefore utilize a "don't just tell me, show me" model. All dancers also mentioned that they would want access to the footage. Last, our results suggest that users should also be given control on how they want their information to be presented. Five dancers mentioned that they best know when they are improving if they watch a video of themselves rather than using the mirror and teacher as a form of validation. Two dancers mentioned that having a third-view perspective is important because it is hard to see yourself in the moment. One dancer pointed out that she would be more motivated if class was filmed every day and that it would also reduce performance anxiety.

Augmented mirrors

To communicate proper mirror use, designers can incorporate augmented mirrors to enable a teacher to "black" out the mirror at their control wherever they are in the studio with a clicker. It may discipline dancers to help them use

their *port de bras* or the use of the head. Designers could, for example, use the audience as a visualization method as shown in Figure 7. This approach may allow dancers to feel as if they were dancing in front of a real audience. In this way, a "mirror-dancer" may be avoided. This challenge is currently navigated through the use of blackout curtains or by making dancers face away from the mirror. However, two dancers stated that these two approaches cause them to lose their relative physical position in space. Teachers also do not have the ability to "black" out the mirror at their disposal, losing precious time from technique class.

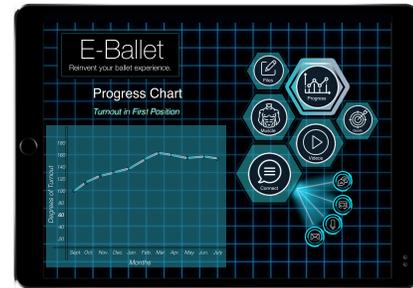


Figure 6. Quantifying turnout in a video tracking tool

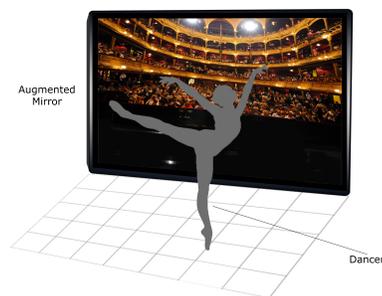


Figure 7. Augmented mirror that visualizes the audience to dancers

CONCLUSION

Ballet studios have not been innovated for the past 200 years. For ballet dancers and teachers, challenges in the traditional environment provide opportunities to induce technology to augment their abilities and improve the experience of learning and teaching.

In this paper, we: identified five challenges for dancers and teachers in learning/teaching; identified a temporal dimension of feedback; identified four novel commonalities between both types of users; provided design implications for tools in the ballet environment to offset these challenges. Since ballet is an example of activity that requires complex motor skills, this research will allow to develop technologies that can be adapted to a wide range of sport activities that require strong coordination (e.g., soccer, basketball, football, gymnastics, figure skating, etc.).

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