SYMBOLISING SPACE: FROM NOTATION TO MOVEMENT INTERACTION

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ABSTRACT

The last decades the development of whole-body interaction technologies, as well as XR (Extended Reality) technologies, including Augmented, Mixed and Virtual Reality, created a strong potential for embodied and immersive experiences to support learning and the use of notation while moving. In our ongoing work, we explore this potential on the user case of familiarizing dance experts and amateurs with movement notation in general and Labanotation in particular. By applying methodologies of user-centered design, including co-design workshops with notation and dance experts, interviews, focus-groups, questionnaires supporting the iterative design of our prototype, we focus on how we can meaningfully transfer the concepts related to space from notation to full body interaction instructions. So far we have developed two prototypes following two paradigms: a. the augmented mirror paradigm using Kinect and b. the immersive paradigm using HTC-Vive, that we have used as technology probes to interact with dance experts in the context of our co-design work. We reflect on this experimentation and we document the emerging challenges of transferring a symbolic language that is meant to be transmitted through paper, into spatial semantic queues. We discuss the challenges that arise between the gaps of symbolically referring to space, within a rich conceptual framework, such as Laban Movement Analysis (LMA), experiencing space kinaesthetically, and transferring these into a digital experience, always within the limitations of the current technologies.

1. INTRODUCTION

While traditional notation of music is an integral part of music education, at least for classical and western genres, using notation for movement and dance practice is rather an exceptional case. Notation and the creation of scores in dance education, creation and practice is a rather rare and idiosyncratic process, unless we are talking about systematic choreological analysis with the participation of dance researchers and trained notation experts. While more than 80 notation languages are mentioned in literature, still Labanotation, remains the most well-established system for writing and analysing movement. Although it does not represent an everyday language for dance educators and practitioners of any genre, it is still a powerful tool for movement scholars. In addition, the last decades many researchers and developers in movement computing as well as Human Computer Interaction have found in Labanotation and Laban Movement Analysis, a powerful tool for conceptualising human movement [1].

Playful technologies show great potential for making learning experiences much more interesting and fun for both adults and digital native young students, through embodied experiences [2], especially in the case of teaching more complex, analytical knowledge, such as dance notation. Previous works have discussed the opportunity of cultivating kinesthetic awareness, i.e. "the perception of our position and movement in space" through interaction [3, 4], using audio feedback.

So the question is, what are the implications of exploring symbolisation of directions in space using notation within a three dimensional XR experience? We argue that moving in space to familiarise oneself with concepts about space on a cognitive level can make the whole process more enjoyable and intuitive than studying on paper. On the other hand, while current XR technologies offer a great opportunity to learn or read notation while moving, there are many implications when it comes to cultivating spatial awareness.These implications originate both from the limitations of current technologies (e.g., limited precision, visual feedback on flat screen or small field of view), and from the complexity and diversity of the notion of Space, both on a cognitive and embodied level.

In this experimental, qualitative study, we focus on the design challenges that emerged during our iterative, participatory approach of communicating and capturing simple directional concepts through the Laban symbols, using two XR application paradigms. As we have observed, many of the usability and user experience challenges emerge from the complexity and expandability of embodied perception of space in movement practice vs. the strict, geometrical representation of it in the digital environment. Following a research through design logic ([5], we have proposed an experimental whole-body interaction application that evolved through-out the process. The objective of the application is to teach the basic Laban direction symbols through a playful embodied experience, implementing two

paradigms that are inspired by dance practice. The first one is the mirror paradigm, implemented in our case with the use of a Kinect motion sensor device and SDK [6] and the second one is the immersion paradigm, implemented using virtual reality equipment, HTC Vive [7]. Both prototypes have been developed using the Unity 3D platform [8]. Section 2 provides an introduction to the concept of space in dance practice, Laban Movement Analysis and Notation and the idea of the imaginary cube as an extension of the personal space to practice directions. It is important to note that unlike music, practicing dance while reading and taking notation is not a common practice. In Section 3 we relate our work with previous research and efforts to teach dance or notation using XR technologies or the paradigm of augmented mirror. In Section 4 we describe the scenario of use and the setting of the installation, while in section 5 we explain our methodology during the process of design and provide details about engaging with the dance and user community. In Section 6 we present the findings of our research and in section 8 we conclude the work.

2. SPACE AND DANCE PRACTICE

The concepts of space and its perception is prominent in contemporary dance and other movement practices and the awareness of orientation of the whole body and limbs is a skill relevant to most dance practices. Its understanding, but also re-thinking, re-constructing and developing ideas around it and its metaphoric and poetic nature is in the core of both choreography and learning. Therefore the definition of space in movement practices extends the definition of the measurable Cartesian space [9].

2.1 Labanotation: a symbolic language for Movement

Based on Laban Movement Analysis (LMA), the theoretical framework to analyzing movement, Rudolf Laban has introduced Labanotation, the symbolic language for notating different aspects of movement, such as directions, body parts, dynamics, timing and others. It is mostly used for dance and motion activities and translates motion into symbols, where change of symbols constitutes motion [10]. Labanotation, apart from being the most wide-spread system for notating dance, is also a valuable medium for the cognitive representation of the structure of movement, especially at the beginning stages of movement learning [11, 2]. The last decades, several digital applications have been proposed for choreography and dance documentation and automatic analysis [12, 13, 14, 15]. The potential of LMA and Labanotation, has also been explored in other domains such as the design of movement-based interaction [16], design of expressive animation characters [17], gestural design [18], and artistic installations [19].

2.2 Laban Movement Analysis and Space

Laban Movement Analysis [20, 21, 22], consists of four basic elements that concern various movement aspects: *Body* (what), *Space* (where), *Effort* (how), and *Shape* (in relation to what). *Space* is further categorized in personal,

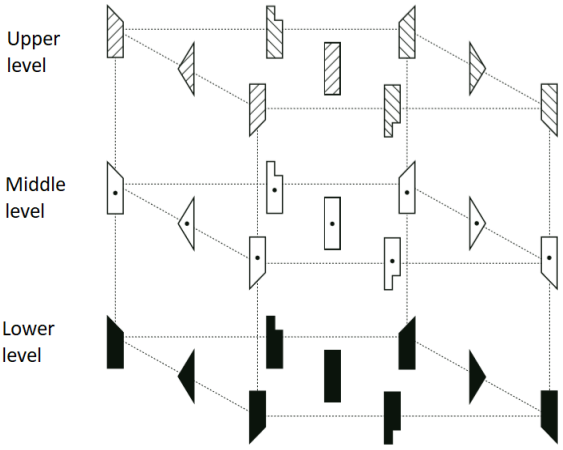

Figure 1. Laban's cube with directional symbols on the corresponding points in 3-dimensional space

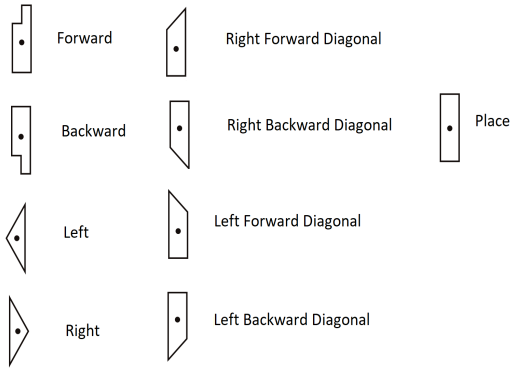

Figure 2. Direction symbols of Labanotation

interpersonal and general space. Personal space, the volume created and occupied by each person or *kinesphere* is defined by Laban as "the sphere around the body whose periphery can be reached easily with extended limbs" [23, 24]. The center of this volume is the center of the mover's body. The kinesphere, the imaginary sphere around the body, can expand or shrink according to the mover's will and mood.[17]. The use of space and the relation to the kinesphere is one of the major aspects in LMA that can apply to the analysis of both functional as well as expressive aspects of movement. Further division and transformation of the imaginary kinesphere into geometrical shapes and relationships in LMA are used both as educational tools to cultivate spatial awareness, as well as for analysing and "reading" existing dance works and performances [25].

Inside the kinesphere the mover's body can create various formations which can be seen as polyhedrons. These polyhedrons are explored through the *movement scales* which are pathways that connect specific points of interest of the polyhedrons (planes, edges, corners, diagonals etc.) and can be outlined with each body part. Laban connected specific polyhedrons of interest with elements like dimensions, planes and diagonals. The most basic polyhedron is the cube (see Fig.1) and is correlated with the concept of diagonals. The cube can be furthered divided in three levels, upper, middle, lower; each level has nine points of

Figure 3. Recordings (video and Optical Motion Capture) of Directionality exercises in the context of the WhoLoDancE project

interest, eight in the periphery and one in the center(see Fig. 1 and Fig. 2).

2.3 Moving in a Virtual Cube

Some dance practices highly rely on the use of the frontal point-of reference usually referred as the "audience" and a mirror is used both for helping young students to get oriented in the space and also to check the correctness of the posture or movement. Practicing Laban scales gives practitioners and dancers the chance to enhance their cognition and perspective of moving in 3-dimensional space. Moreover, they can experience the coherence of kinesphere spatial structure. Apart from the scales, the Laban cube offers the possibility to the mover practitioners and dancers to practice various directionality concepts, enhancing in that way their perspective of the 3-dimensional space. In addition, besides LMA, the concept of the cube, as a starting point to create movement forms in choreography, has been used by other choreographers such as Trisha Brown, which she has sketched as the imaginary cube and its points in her work "Locus" [26]. The choreographer William Forsythe in "improvisation technologies" [27] provides several examples for geometries in space and how they can be used in spatial thinking in a creative context.

In the WhoLoDancE project [28] several exercises, using the concept of the imaginary cube have been proposed by the contemporary dance experts to cultivate the sense of space and self-practice directionality, such as following specific sequences of pointing directions by particular body parts, as shown in Figure 3. In particular, during the motion capture of those exercises, which aimed to create a movement library with useful educational content, a metallic physical cube was set in the studio to make more concrete the idea of orienting body parts towards points in a visible, tangible cube.

3. TEACHING SPACE IN A VIRTUAL ENVIRONMENT

It is true that some dance practices heavily rely on the use of the mirror both for supporting orientation and for self-correcting posture and motion. In these cases, the metaphor of the "augmented-mirror" and the use of Kinect [29, 30] have shown positive results regarding both usability and effectiveness in self-practice [31, 32, 33]. Mirror, however, as well as, video and Kinect, unless combined with more than one devices, provide only one 2-dimensional perspective of the body and movement. In this case, a combination of Kinect with extended reality equipment might be a solution [34]. Familiarizing someone with Labanotation concepts and symbols of space includes the understanding of high level space concepts and the architecture of the body. It is definitely an important aspect in dance teaching that extends to other domains such as movement literature, bodily knowledge, but also analytical skills regarding space, that is useful for both children and adults, and non-dancers. In movement practices, on one hand there is the improvement of the kinesthetic awareness, on the other hand there are the cognitive skills such as memorization, and analytical conceptualization on space, aspects that can extend to other domains such as interdisciplinary thinking, geometry, architecture etc. Recent advances in technology for gaming and motion tracking, as well as implementing Extended Reality (XR) environments have the potential to create effective training environments and compelling entertainment experiences. It is commonly accepted, that learning Labanotation can be hard and frustrating not only due to its novel vocabulary but also because Labanotation tries to describe motion in 3-dimensional space with 2-dimension symbols. Ballas et al. [35] describe a Kinect-based system for teaching Labanotation in mixed reality. The proposed way of teaching the symbols is by following an avatar that performs according to the desirable Laban score. In that way, the user is intended to learn the symbol by seeing and mimicking a mirrored, avatar teacher. In addition, mobiles apps have been developed either to create a score [36], to visualize and explain the Laban scales [37] , and to read notation while moving using Augmented Reality (AR) glasses [38].

4. SCENARIO AND GENERAL IDEA

The cube is one of the simplest polyhedrons of Labanotation to explore three-dimensional space and conceptualize about levels and directions. The exercises proposed by the

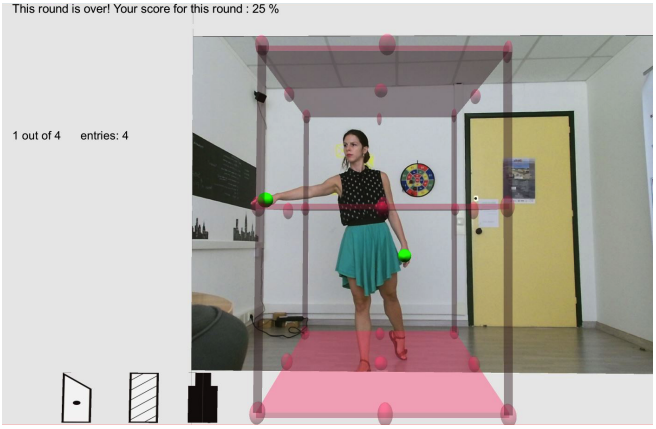

Figure 4. Cube exercise in Augmented Mirror setting using Kinect

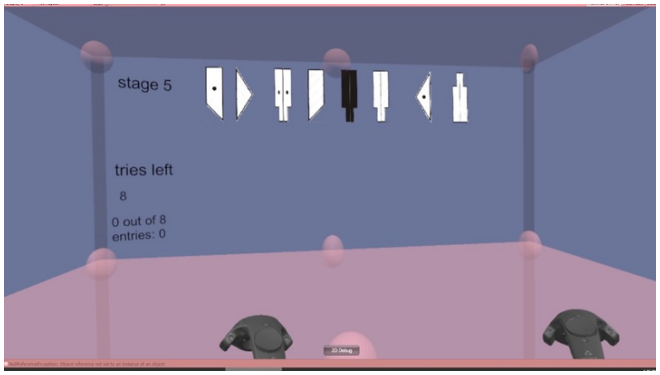

Figure 5. Screenshot from the first person perspective in VR.

dance experts for directionality with the cube, are considered as very simple, basic, generic exercises which can escalate into more complex combinations depending on the level of the performer. However, with the fact that Kinect is based on a depth camera, providing visual feedback on a two-dimensional screen is a challenge.

4.1 The cube in a VR setting

Taking into account the experience with the Kinect and its specific characteristics and limitations, we decided to migrate and test the whole scenario in a virtual reality setting, using virtual reality equipment, to experiment with a more immersive experience. The application was adapted to be used with the HTC Vive VR equipment, including a VR headset attached to a cable and two hand held controllers which ensure that the Vive sensors record the position of the users' hands . The use of immersive VR was greeted with excitement by the collaborating dance and LMA experts who explored its possibilities in comparison with the experience with the Kinect (Figure 4).

However it was immediately clear that the new setting brought also a new set of challenges. As it is to be expected, this type of immersive VR required a cumbersome headset and holding the controls, which seemed to the experts as a step backwards from the unencumbered use with the Kinect. Although we had foreseen that in the Vive setting it would be much easier for the users to complete the exercises by reaching the correct points on the cube, due to the higher accuracy of the motion capture, there were still difficulties. We suspect that this was due to the fact that the cube was placed in an otherwise empty virtual environment which might have been a bit disorienting for the users, as P5 suggested. On the whole, they were very enthusiastic with the tool so maybe this was the reason they overlooked its limitations. The next section will attempt a further reflection on the use of the Vive comparatively with the Kinect version.

4.2 Setting and workflow

The scenario of the exercise is as follows: In the Augmented Mirror version the users see on screen their video camera captured self within a virtual cube, as it is shown in Figure 4. In the VR (Virtual Reality) version the users are immersed in the virtual cube. In both versions, the users are asked, by us orally, to point with their hand to the direction that is given, having the directional symbol, as a "semantic aid" [39] to reach this direction. The direction is the edge of a cube which is virtually attached to their personal space. There are three phases in this task: the a) Exploration, b) the One-to-one, and c) the Memorization.

In the exploration mode the users are asked to point to the directions and the symbols appear in order to let them explore and familiarize. When their hand enters the area that represents a specific direction in the cube-space, the symbol of this direction will appear in that place allowing them to observe it as long as their hands stays in that area. This stage is called "exploration" mode, since the users are free to go ahead and discover all the directions, as many times as they want. Therefore, they get informed about the directions that they are following as well as about which symbol represents each direction.

In the one-to-one phase of the exercise, the users see the symbol and they are asked to "reach for" the virtual ball attached on the corresponding direction and edge of the cube. If they succeed, the system displays the next symbol. A "win" sound and the temporary color change of the cube from purple to green are used as corrective feedback to the user, apart from the symbol change, every time they succeed. A score is displayed at the end of this stage to inform the user about their performance. The type of the score given, is based on how many "hits" they had in the total amount of the symbols that were displayed. The number of the symbols that the users have to go through in this stage is flexible and it depends on the desired difficulty, the available time schedule etc. An indicative number would be all twenty-seven symbols, therefore all symbols, one time each.

After trying the previous stage, during the memorization mode, the users are now ready to try what they have learned so far by performing a sequence of moves in order to go through the combination of symbols-directions that appear on the screen. The first sequence consists of four symbols, the second of eight and the third, of twelve. Only if the users succeed in finding all symbols of a group, they can move to the next one. If they fail in finding one symbol,

they have to go through the whole sequence again. When they go to the right direction that the symbol indicates, a win sound is played, the cube changes color from purple to green for two seconds and the symbol displayed is replaced with a grayed-out one to indicate that the users can move to the next symbol. In this stage, the user can see live information of how many symbols they have found correctly out of the total, for each group (four, eight and twelve).

5. METHODOLOGY

Our approach is based on of a longitudinal co-design collaboration with four dance and LMA experts that lasted a year and consisted of a series of co-design sessions. This long term collaboration was combined with once-off hands-on demonstrations to a varied user group, involving children and adults, dance and movement experts and technology experts, in a total of more than 30 users in a series of different events. Through this iterative design approach, we aimed to document and discuss the potential and the challenges in conveying the spatial concepts through the proposed kinesthetic experience.

5.1 Working with dance experts

Our co-design group involved five dance and LMA experts:

- P1: semi-professional dancer and teacher, having 25 years of dance practice in ballet, contemporary and other types of dance as well as theoretical Labanotation knowledge,
- P2: a dance practitioner, contemporary and ballet dancer, with 8 years of experience and basic knowledge of Labanotation,
- P3: a dance high education professor and researcher, expert in LMA and Labanotation as notator,
- P4: a renowned contemporary choreographer, with more than 25 years in making and teaching movement for the stage to children, adults, actors and dancers, using LMA for educational and creative purposes,
- P5: young dance professional teacher and choreographer, expert in community dance, having degrees in dance and Psychology.

The co-design sessions with the experts included several three to five hour sessions which alternated theoretical discussions and bodystorming [40] on the concept and method, initially, and later, as the design and implementation progressed, hands-on evaluation of the prototype. The experimentation with the tool was at points guided through specific tasks, at others more free-form so as to explore its different perspectives and identify challenges.

5.2 Involving other user groups

In order to test the prototype and concept with a more varied user group with or without any background in dance or LMA, and/or with or without experience with Kinect-based applications in games, we organized hands-on demonstrations of the tool in the lab and also in the context of different conferences and events. We involved five users who were both dance and movement experts, five technology experts and seven people of the wider public, with special focus to children and teenagers as digital natives. More specifically, we involved 15 young digital natives, aged 8-15 years old, with some of them having experience in ballet, but none in LMA or Labanotation.

Figure 6. Choreographer (P3) and Expert Labanotator, participant (P4) using Vive during the co-design session

The installation was offered as a hands-on demonstration. In all sessions an introductory stage with a presentation preceded the main tasks to explain the general context and objective of the study and to give to the participants a short introduction to Laban s cube and Labanotation. Feedback was collected while observing the users with the tool and also, in the form of questionnaires and brief interviews, also recording their previous experience with movement practices, as well as with Kinect based games.

6. OUTCOMES AND DESIGN CHALLENGES

In this section we document design challenges that emerged during the co-design process as well as the remarks and outcomes from the evaluation with other user groups during the demo sessions.

6.1 Supporting memorization

All the dance experts during the co-design sessions, and also the adults with dance or technical background expressed their interest in the memorization tasks. After the experiment, even users who had briefly used the application and had no previous experience with LMA showed that they actually memorized a good number, and in some cases all, of the symbols. For the young digital natives, the tasks were definitely the most clear and fun phase according to their interview answers and our observations.

6.2 The need to encourage 3-dimensional movement

Although the exercise, and the idea of exploring the cube, is designed to encourage the three-dimensional use of the body, this was not fully accomplished with the application. This was due to the use of the 2D screen combined with

the fact that most people, especially those having experience with this type of device were expecting to have a more static, upper body, gestural interaction with the system. Regarding the main experience, users who were not familiar with the Kinect and tended to turn and bend their body very often, faced some inconsistencies in the results of their movement. Kinect works best when users face the camera and make simple movements that don't involve much bending or turning.

6.3 User's familiarity with MS Kinect

We observed that users who were familiar with using and working with MS Kinect were significantly more successful in completing the tasks than the ones that were familiar with movement and Laban concepts but had no experience in using Kinect. This was mostly because they knew the correct way to perform certain moves like bending and turning that Kinect couldn't capture with great fidelity. Movement experts, on the other side, were more focused on the representation of their movement and seemed frustrated that Kinect didn't always respond well. Therefore, this lack of familiarity with the medium made it quite hard for the movement experts to focus on the tasks and complete them.

6.4 Self-image on screen vs. seeing your space in first person view

The objective of this installation was to teach the basic Laban direction symbols during a playful embodied experience. Through the co-design sessions with the dance experts and taking into account the outcomes of the involvement of other user groups, we reached the following realization: On one hand this type of installation is in fact effective to support memorization and learning of the symbols. But on the other, the Kinect motion sensor device in fact implements the mirror paradigm which implies that the users have to be aware of their own surrounding 3D space while at the same time focusing on a two-dimensional screen to get feedback. This constant shift of attention between the screen and the physical space is not the optimal solution for cultivating spatial awareness. As a conclusion, the MS Kinect hardware might be affordable and portable, but was not fully serving the idea of the cube as an extension to the user's own body and personal space. It is true that some dance practices heavily rely on the use of the mirror for both supporting orientation and self-correcting posture and motion. The mirror, as well as, video and Kinect, unless combined with more than one devices, provide only one 2-dimensional perspective of the body and movement. In these cases, e.g., for ballet, where usually a more traditional teaching approach with the mirror is applied in the physical world, the metaphor of the "augmented mirror" and the use of Kinect [29, 30] have shown positive results regarding both usability and effectiveness in self-practice [31, 32, 33]. In such cases, the students looking at themselves and their posture and correcting it is the objective. In our case, however, they need to also consider the symbols themselves and link them to the 3D direction and body posture they correspond to looking at a 2D screen. So the cognitive load is greater.

7. DISCUSSION

7.1 Mirroring vs. Immersion

Kinect and Vive experiences, as it was revealed during the working sessions with the experts, were different in many aspects. Firstly, the time needed to familiarize with the environment was significantly less in the Vive, as the whole exercise seemed more self-explanatory, since the body is immersed in the kinesphere or the cube rather than presented on the 2D screen. Observation revealed that their body posture and movement was different, more free and natural. The feeling of immersion was strengthened by the fact that in the Vive experience the users see the symbols in their own physical environment rather than placed on a two-dimensional representation of their bodies. As one of the dance experts, choreographer and teacher explains: "In the Vive version, I definitely had more conscious feeling of my body and kinesthetic awareness, the attention was on my own body, rather than on the screen. In the Kinect I was searching for my body on the screen, so I somehow lost my sense of embodiment, it looked more like a funny game, but I was more connected with the image of my body rather than the sense of it." Another expert also notes that this feeling of immersion, might be an interesting way to trick non-dancers and people who are uncomfortable or shy with movement into some type of dancing. "Here you are not able to see the real world, you can't see if others are watching, you are lost in your own space, and this fact, combined with some playful elements might be a way to motivate people who do not usually feel like moving or dancing, since the focus is on the goal".

7.2 Free hands vs. controllers

Overall the use of the controllers in Vive, vs. having free hands in Kinect was not annoying or at least was compensated by the immersion and freedom of movement in the three-dimensional space, according to the dance experts. P4 notes: "It was strange though that I could see the controllers but not my hands, however this is a fact I very easily forgot and overcame." In fact using the controllers, brought to the discussion the metaphor of drawing in space, and further creative ideas, such as coloring the different directions. Another minor issue that we had in the Vive setting was the presence of the cable.

7.3 Continuous vs. discretised space

Another point that all the dance experts commented on was the continuity of space and continuation of movement as a feeling. While Laban's cube, and the 27 directions can be seen as benchmark points in space, that allow abstract communication, and thinking of the geometry of the body, by creating linear visual metaphors, there is much more in exploring space, both in Laban's theory and in kinesthetic awareness in general. One of the experts expressed the concern that looking for points and lines, rather than

areas, volumes or even texture of the air that covers the space might convey a very linear, or "empty" way of moving. In fact, for the cultivation of movement literacy both levels are needed: there is one cognitive, analytical aspect of thinking on movement, that is where even as a choreographer you create the "skeleton" of the space and then there is kinaesthesis, the qualities and textures of the movement that you fill this skeleton with to make it a complete physical, embodied experience.

As P4 adds: "If I have to compare studying Laban symbols and the concepts using this application, rather than paper reading, then I would definitely vote for it, it is embodied, it is clear, it is fun and effective. Though I would never say that someone can learn to dance with this application, I see much more potential for learning the Laban symbols: it can also be a tool for teaching geometry, or architecture especially for young, digital natives.". P1 and P4 agree on the following: "The process of analysis and learning a conceptual framework is very important but completely different from the real, embodied experience although in a continuous dialogue. The concepts of *Body, Space, Effort and Shape* are very useful in helping young dancers understand the tools that they have, the range of possibilities, but in the real world in the embodied experience they all happen at the same time. For example: the focus might be on *Space*, and the question is to go from point A to point B having already a specific *Effort*, a specific quality."

7.4 Memorizing symbols vs. improving natural movement

During the completion of the tasks the dance experts were much more demanding, they needed to explore the difference of "pointing at" the direction, vs. "reaching out", to be in but also go out of their kinesphere or cube. During the interviews, some of them admitted that the Kinect was fun, but somehow restricted their movement, while others had the feeling that they had to adjust their movement to the system, though it was fun as a game. One of the experts observes "at certain points I had the feeling that I needed to move in a very restricted space, in a very particular way, this certainly affected my qualities". This observation reminds us of the question raised by Norman "how natural is natural interaction". To this point we need to add that this expert had never used Kinect or Vive.

7.5 Beyond the Cartesian space

During the co-design and evaluation sessions with dance experts, we have discussed ideas for transforming the experience into a more imaginative, creative and playful environment where other modalities of kinesthetic awareness related to space can be cultivated. We have discussed both the use of visual metaphors such as the one of drawing in space with traces while moving from one edge of the cube to the other. P3 highlights that "the edges of the cube, the places and the diagonal are important but what is also important, is the in-between space and its volume, its texture, especially if our focus is to use this for young dancers". P4 proposes to add another mode where the symbols will be replaced by images of tangible objects and the mover can create small stories by pointing at, reaching, or grasping these objects". Taking into account the impact of story-making as semantic aid for directional gesture interaction [39] a next version of the tool combining Kinect and Vive can be explored both for memory practice and creative context. Another important idea that emerged during the process, is that of "constructing" space. Usually virtual reality technologies are used as a means for entering a ready-made new environment, however, in many movement as well as somatic practices, one is asked to fill this place with their imagination.

Moreover, a very interesting area for future research is the connection between movement and sound. Special designed sound and audio cues could be given as a sonification feedback for example to reflect directions but also other qualitative aspects of movement (e.g., Effort). Furthermore, a correlation of directions and musical notes or musical scales can be considered since each direction could be a specific note and each level a specific octave. In that way the users "compose" a musical theme while they are moving. This bridge between music and movement could possibly help in understanding Laban symbols.

8. CONCLUSIONS

This paper contributes to the field of interdisciplinary research intersecting movement practice and analysis and embodied interaction design. We articulated concrete HCI challenges on conveying spatial kinesthetic and embodied knowledge. Through an experimental, co-design process with dance experts and practitioners we explored and documented the opportunities and limitations that are available in current commercially available technologies such as motion sensing and VR. We conclude that interactive technologies, can play an effective role in conveying conceptual, analytical knowledge such as teaching a symbolic language to the young digital natives as well as adults. In particular, motion depth cameras like the MS-Kinect, although they are effective for a dance learning context where the mirror-paradigm is used, according to the literature, they might be problematic when there is a stronger need to cultivate the sense of 3-dimensional space. In fact, they can lead the users into a more gestural, 2-dimensional pattern of moving. However we cannot overlook the advantages of such settings in relation to the low cost and complexity, as well as the fact that, as the experiment showed, they can become a powerful tool for memorization exercises and foster interdisciplinary, informal learning by making "paper subjects" such as learning notation symbol, more fun, interactive and engaging [2].

The fact that for the wider audience these types of settings are considered as "electronic games" is an advantage and a weakness at the same time: it is an advantage as they can attract young digital natives and engage them in analytical subjects in a more embodied and fun manner. On the other hand, there is always the risk of the digital medium imposing its own qualities on the movement, which sometimes derives from the limitation of the technology itself, rather than the initial intention of the design.

The fact that a playful embodied task oriented experience

can "trick" people into moving or even dancing without realizing it is also a very important observation, made by the movement experts. This opens a wide range of applications to rehabilitation, and the potential of targeting user groups that are not keen on moving, nor convinced easily to start an activity.

Last but not least aesthetics and look and feel of the environment are of high importance. Though this aspect was not within our main focus in this study, interesting ideas have emerged during the co-design sessions for future development, in order to make it visually more attractive. We believe that although the setting is simple and the focus is on the cube, which is something that was considered a strength by the participants, our digital environment can definitely benefit from a future collaboration with visual and 3D artists to better convey the metaphoric aspects of space in a more inspiring manner.

Moreover, a very interesting area for future research is the connection between movement and sound. Special designed sound and audio cues could be given as a sonification feedback that reflect if a movement is right or wrong, for example. Furthermore, a correlation of directions and musical notes or musical scales would be very interesting since each direction could be a specific note and each level a specific octave. In that way the users "compose" a musical theme while they are moving. This bridge between music and movement could possibly help in understanding Laban symbols.

During this work we acknowledge that the continuous dialogue with dance and movement practitioners can open pathways in terms of perception and therefore representation of spatial aspects and can enrich the field of whole-body interaction as well as the design of innovative applications for notation. Dance and movement practitioners and researchers, can bring innovative insights in embodied and multi modal experiences through challenging and rethinking the relationship between the Cartesian, measurable, perceived and metaphoric space. Based on the outcomes, we consider a new co-design cycle to develop a more complete scenario of teaching Laban Movement Analysis using XR technologies. In addition, more systematic evaluation experiments need to be held in order to further study the outcomes of this initial experimental study.

Acknowledgments

We thank the dance experts that dedicated long hours throughout the process, as well as all the participants for their valuable feedback.

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