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Nabia: Virtual Reality Movement Exploration and Choreographic Tool

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DISSERTAÇÃO SUBMETIDA COMO REQUISITO PARCIAL PARA OBTENÇÃO DO GRAU DE MESTRE EM AUDIOVISUAL E MULTIMÉDIA

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Declaração

Declaro ser o autor do presente trabalho de investigação, condição necessária para a obtenção do grau de Mestre em Audiovisual e Multimedia. Atesto que a presente dissertação, com o título "*Nabia:* Virtual Reality Movement Exploration and Choreographic Tool" é um trabalho original, nunca submetido (no seu todo ou em qualquer das suas partes) a uma instituição de ensino superior para obtenção de um grau académico ou de outra habilitação.

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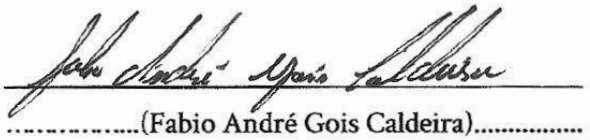

.....(Fabio André Gois Caldeira).....

Resumo/Abstract

PT: As tecnologias de Realidade Virtual e Aumentada têm ganho uma maior relevância no mercado com o aparecimento de soluções acessiveis ao consumidor geral, como o *Meta Quest 2*.

Os videojogos têm dominado as soluções XR, mas, com a democratização do acesso a ferramentas de Realidade Virtual e Aumentada, existe uma crescente procura pelo uso de XR para soluções fora do entretenimento. A área de Design de Interação é assim, como no desenvolvimento de soluções web e soluções para mobile, uma componente fulcral para o desenvolvimento da Realidade Virtual e Aumentada e na definição das normas e heurísticas de XR Design.

A inovação técnológica e o desenvolvimento da arte sempre se relacionam com proximidade.

O aparecimento do cinema através do desenvolvimento técnologico, o desenvolvimento de musica eletrónica pela invenção dos sintetizadores são exemplos dessa mesma proximidade.

O cruzamento entre tecnologias de Realidade Virtual e Aumentada com a arte aparenta ser um passo natural do desenvolvimento de ambas as vertentes.

Assim, propõe-se o desenvolvimento de uma solução VR, que procure explorar e definir formas de interação entre o ambiente virtual e a linguagem de movimento da área artistica da Dança.

Desenvolveu-se então, como objeto de projeto final, uma ferramenta de Realidade Virtual, designada de *Nabia*, que permite aos utilizadores explorarem e comporem o seu movimento, através da interação e inspiração com o meio virtual.

Palavras-Chave: Design de Interação, Realidade Virtual, UI/UX Design, Dança

Eng: Virtual Reality and Augmented Reality technologies have gained greater prominence in the market with the emergence of accessible solutions for the general consumer, such as the Meta Quest 2.

Video games have dominated XR solutions, but with the democratization of access to Virtual and Augmented Reality tools, there is a growing demand for the use of XR in non-entertainment solutions. The field of Interaction Design, as in the development of web and mobile solutions, is a crucial component in the development of Virtual and Augmented Reality and in defining XR Design standards and heuristics.

Technological innovation and the development of art have always been closely related.

The emergence of cinema through technological development, the development of electronic music through the invention of synthesizers are examples of this proximity. The intersection of Virtual and Augmented Reality technologies with art appears to be a natural step in the development of both aspects.

Therefore, it is proposed the development of a VR solution that seeks to explore and define forms of interaction between the virtual environment and the movement language of the artistic field of Dance.

It was developed a Virtual Reality tool, named *Nabia*, as the final project, which allows users to explore and compose their movement through interaction and inspiration from the virtual environment.

Keywords: Interaction Design, Virtual Reality, UI/UX Design, Dance

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To my family, my mom Teresa, my dad Isidro, my sister Tânia, my brother-in-law Leonel, my nephews Pedro and Antônio, my father-in-law João, my mother-in-law Maria Antónia, my grandma-in-law Filomena, my sister-in-law Matilde and my cousin-in-law Sofia, a special thanks for all the support and patience with me. Thank you for all the hot food, clean clothes, family activities and general support that allowed me to reach this project.

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To all,

Live Long and Prosper

Introduction

For the Master's Degree final project, the main idea is the conceptualization and development of a Virtual Reality solution, called *Nabia*, using concepts from Interaction and UX/UI Design, that seeks the exploration of Dance and Movement as means of Interaction.

The goal is to create a virtual space that gives the user the capability of experiencing movement and the consequence of it in the simulated reality. From a functional standpoint, the virtual reality solution would rely on the manipulation of the virtual environment using movement as the origin of interaction and the recording of the environment's response to the user's movements. The recording of the environment could be experienced by a second user, creating a movement exploration and creation pipeline between multiple users.

Virtual Reality is one of the disruptive mediums of the present day. With concepts like the Metaverse, the increasing accessibility to Virtual Reality systems by the mainstream consumer and the rising investment in software for Virtual and Augmented Reality solutions there's the need to understand in depth the range and diversity of applications and explore the potential that virtual reality has in different study areas.

To enable the exploration of Virtual Reality and Movement it is elemental to understand two aspects, the Design Process associated with the development of Virtual Reality solutions, through practical examples and theoretical perspectives, and the technical and contextual characteristics of Choreographic Tools.

To understand and explore Virtual Reality, the history and evolution of the technology and possible applications, the main contributions were taken from were *Creating Augmented & Virtual Realities* by Pangilinan, Lukas and Mohan and *The VR Book: Human-Centered Design for Virtual Reality* by Jerald.

Creating Augmented & Virtual Realities explores the concepts of Human-Computer Interaction and how they influence and are influenced in the development of virtual and augmented reality solutions and seeks to define the best strategies and practices to be applied in the development process of a Virtual and Augmented Reality solution (Pangilinan et al., 2019, pp. 4, 14–20, 167–188).

The VR Book: Human-Centered Design for Virtual Reality addresses the history and development of Virtual Reality by seeking the core aspects that define Virtual Reality and thus attempting to create a guide for the development and design of VR solutions.

It also explores the issues of Interaction Design and Human-Computer Interaction, understanding the particularities, from a Design perspective, of the development process of Virtual Reality solutions. (Jerald, 2016, pp. 7–54, 225–230).

From the practical standpoint of Virtual Reality, there are two crucial case studies full of insights into the design process for Virtual Reality, Google AR/VR and Meta/Oculus.

Google during the active season of the Google AR/VR project, between 2014 and 2020, where it developed the Cardboard and Daydream systems, explored several issues related to the development of VR solutions.

Topics such as the relationship of the user to the 3D interface and the development strategies of the interaction elements were explored and documented by Google in its annual Google I/O presentations and on its website/repository dedicated to sharing the project's findings (Google, 2022).

It is also possible to analyse the strategies of Meta, the parent company of Facebook and Oculus through their development conferences available online.

After the exploration of Virtual Reality, Dance Exploration and Choreographic Tools are the focus of analysis.

For that the main contributions were taken from *TEDANCE: Perspectives on Technologically expanded Dance* by Tércio and *Material for the Spine* by Paxton.

TEDANCE: Perspectives on Technologically expanded Dance is a compilation of academic papers exploring the application of technological means in Dance. It seeks to intersect "four fields of research: Motion Capture, Augmented Reality, Character Animation and Choreography"(Tércio, 2009b, p. 6)

Material for the Spine is an improvisation tool compiled of videos guiding dancers through the movement language of Steve Paxton (Bleeker, 2017, p. 5)

Since the XX century, with the artistic rupture and creation of modern and contemporary dance, various artistic movements have become more interdependent and transdisciplinary (Paxton, 2019).

With the development and integration of new technologies in ordinary life, new artistic disciplines that integrate the digital medium appear. Some examples are video games, digital art and animation.

Dance is recognised with a disruptive and vanguardist tone (Paxton, 2019).

The integration of XX and XXI century technologies with the Dance movement is visible in ScreenDance works, such as the exploratory filmic works of Merce Cunningham[1] and animation works, such as Snow by Luis Marrafa[2].

The development of a Virtual Reality application with Dance movement as its language then becomes a logic step, not only due to the growth of VR but also due to the exploratory nature of Dance.

Furthermore, since Virtual Reality is still an emerging medium, both in terms of its applicability and in its theoretical concepts, a development project will allow us to find similarities and differences between the construction process of this solution vis-à-vis the common digital product design process, thus fostering the exploration and definition of new standards and forms of applicability of the laws of interaction.

The exploration of the intersection of Virtual Reality and Dance Movement is enhanced by looking at different selections of choreographic and movement exploration tools. These tools are used to help dancers explore a vast spectrum of movements and to make the communication flow between choreographers and Dancers easier.

From the context of both Virtual Reality and Danced Movement, we then reach the project's main question. Can virtual reality be used as an artistic space where movement is the primary means of interaction?

To achieve a potential answer to the question, some goals are defined for this project.

The first point will then be the conceptualization and structure definition of the creation process, taking into account concepts of Interaction Design, aiming at the crossing of these areas and the development of a multimedia solution, in Beta state, that explores the concepts of Dance improvisation.

The second point will be to explore the similarities and divergences in the construction process of the VR interface compared to conventional interfaces.

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[1] Such as Variation V from 1966 and Beach Birds for Camera from 1993

[2] https://www.youtube.com/watch?v=m92QReT-SKE

Seeking to meet the application frameworks of Research-Led Practice and Practice-led Research (Smith & Dean, 2009, pp. 5–9) the third goal will be to understand interaction solutions using dance movement.

Finally, another aim will be to understand the potential of virtual reality as a creative medium where movement is the primary language.

Finally, looking at Choreographic and Movement tools some of the most complete and vital for the Dance field are the already referred *Material for the Spine* by Steve Paxton (2008) and *Mind and Movement* by Wayne MacGregor (2014). These are good examples of Dance Tools because of the versatility inherent in their structure.

Theoretical Framework

Virtual Reality Design and Interaction Design

Virtual Reality, also known as VR, is generally conceptualised as a way to describe imaginary and virtual worlds that only exist in our minds and computers. (Jerald, 2016, p.9).

As a very broad definition for Virtual Reality, there's a wide variety of perspectives about the specifics of this medium.

In 1985 Jaron Lanier defined Virtual Reality as a means to replicate, substitute or modify our reality, building a new one (Arnaldi et al., 2018, pp. 18–20).

This perspective assumes that all realities created in VR are in some way based on the shared reality we live in. Or the created virtual reality tries to mimic the dynamics of the real world or denies the set rules of the natural world, building fictional or almost supernatural dynamics (Arnaldi et al., 2018, pp. 18–20).

We can also find a simplified definition of Virtual Reality if we look into Science Fiction.

Vernor Vinge in his work, True Names, explores the concept of cyberspace, first coined by William Gibson (Thill, 2011).

In Vinge's vision, cyberspace is an immersive reality that manifests itself using technological means (Arnaldi et al., 2018, pp. 18–20).

We can understand that Vinge's concept of cyberspace doesn't deny nor affirms Lanier's perspective, because it doesn't focus on the idea of replicating or replacing reality with a new one. Vinge's cyberspace only implies that Virtual Reality always needs a technological means to exist, setting aside whether the world created using the technology is or is not based on real-world dynamics.

This view can be seen as open-minded, versus Lanier's perspective, because it leaves more room for what we can define as Virtual Reality.

Paul Milgram and Fumio Kishino, in 1994 defined a fundamental concept for Virtual Reality, the Virtual Continuum.

Virtual Continuum is a spectral way of envisioning all different kinds of reality.

At one end of the spectrum, we find the natural reality, the real world, that is experienced directly through our senses. On the opposite side of the spectrum, we see a reality experienced using a full computational system, a virtual world (Milgram & Kishino, 1994, pp. 2–3).

With the Virtual Continuum, we can find more mainstream concepts that will be hybrids between the two ends of the spectrum. Augmented Reality, Augmented Virtuality, Virtual Reality and Mixed Reality (Dubois et al., 2010, p. 3-4; Milgram & Kishino, 1994, pp. 2–3).

Augmented Reality is defined as the insertion of virtual elements in the Real World. Different from Virtual Reality, the goal of mixed reality is the enhanced experience of the real world using virtual means (Rubin, 2018, pp. 152–153).

One simple example of Augmented Reality is the optional camera filters in social apps such as TikTok and Instagram. These filters add a virtual layer into the real world giving the user the ability to modify their surroundings and even change their body and face characteristics.

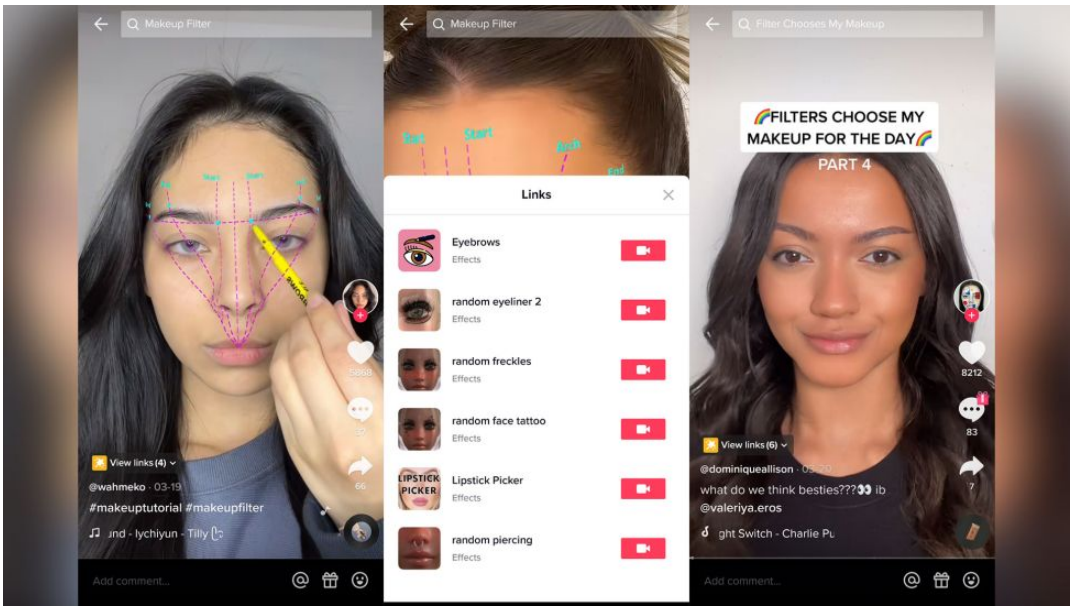

Figure 1 - TikTok Filter using Augmented Reality and AI to change facial features. (Parnell-Brookes, 2022)

The reverse experience of Augmented Reality is called Augmented Virtuality. In this case, the user is in a virtual world and we add real-world elements to it (Arnaldi, Guitton and Moreau, 2018, pp. 59-60 && Jerald, 2016, p.30).

One easy example of augmented virtuality is the Guardian System in the Meta Quest 2 Headset.

Figure 2 -Quest 2 Guardian boundary is used to define a safe space within the virtual world (Hawthorne, 2021).

The Quest Users can define, in the virtual world, where physical objects are located in the real world so they are safer. The real objects will have a virtual representation in this virtual world.

Finally, Mixed Reality, also recognised as XR, is an umbrella term for any kind of Augmented Experience (Dubois, Gray and Nigay, 2010, pp. 1-2), being also the definition of the centre of the Virtual Continuum (Milgram and Kishino, 1994, pp. 4).

For the development of experiences in the virtual continuum, there are three main elements, Systems of Reality, Means of interaction and the User. (Jerald, 2016, p. 30)

The System of reality is the central element of the development of Virtual and Augmented Reality experiences (Dubois et al., 2010, p. 36). It is defined by the hardware the user uses to experience the created reality. This is mainly technological interfaces like Headsets and room-scale VR systems like the CAVE System (Bailenson, 2019, pp. 11–13; Cruz-Neira et al., 1992).

The Means of Interaction, as the name suggests, is the way the user has to interact with the created reality (Jerald, 2016, p. 43; Pangilinan et al., 2019, p. 21).

The Means of Interaction in VR and AR are similar to the solutions found in the Gaming Industry. Gamepads like the ones used in Nintendo's Wii System and camera-based Body tracking systems like Microsoft's Xbox Kinect (Pangilinan et al., 2019, pp. 23–26).

Meta also introduced hand-tracking, eye-tracking, face-tracking and voice recognition as means of interaction with the Quest 2 and Quest Pro VR systems. With these interaction solutions,

the software used with the System of Reality is more capable of detecting and using the user's fine motor skills.

Finally, the third pillar for the development of experiences in the virtual continuum is the user.

Borrowing the concepts used in user-centred design, in Virtual and Augmented Reality the XR Designer has the responsibility of applying the laws and Heuristics from Human-Computer Interaction and Interaction Design. This means that, as in all Product Design, in XR, emotion, cognition and context are central elements that define the quality of the user experience (Pangilinan et al., 2019, pp. 35–36).

Having an intimate connection with videogame development, XR and videogames share concepts. One of these concepts is called MDA Framework.

MDA Framework is a conceptual spectrum, used in Game Design, that connects the player experience with the game designer solution (Hunicke et al., 2004).

The Framework is separated into 3 levels, Mechanics, Dynamics and Aesthetics.

Mechanics are defined by the base rules of the game universe. It is how the game behaves, how things and Non-Playable Characters interact with the world and the information about the world itself.

Dynamics are the definition of how the player can interact with the mechanics of the game, being the link between the static state of the game and the result of the action of the player with the game.

Finally, Aesthetics are the emotional response from the player when interacting with the Mechanics and Dynamics of the game, being where we find the player or user experience (Hunicke et al., 2004).

Looking at the MDA Framework we can understand where the Game designer has more decision power and where the user has more interaction capabilities.

From the Game Designer's perspective, most of the decisions are taken at the Mechanics level, where it has full control. All the decisions made by the Game Designer are with the intention of changing the aspect where they have the least amount of power, the Aesthetics.

Whereas, from the Player's perspective, most of its agency is at the Aesthetics level, the user experience being the sensed reality influenced by the Dynamics and Mechanics of the Game (Korn & Lee, 2017, pp. 27–46).

Understanding the MDA Framework proves the importance of the player experience in the development of Games, and therefore, the centrality of the user in the development of XR solutions.

For this reason, it is easy to discern that, for the development of Experiences in the Virtual Continuum, such as in Product Design and Interaction Design, the concept of Human-Computer Interaction and the role of the user are central.

Human-Computer Interaction, also known as HCI, is a field of study dedicated to the understanding of users and their interactions with technology. HCI tries to find consistencies and discrepancies in user behaviour in a way that allows the development of structures of information that are more adequate for the technology goals and that give the user a better experience (Rogers, 2012, pp. 1–2).

HCI is a multidisciplinary field that informs software design and development, relying on different scientific areas such as Psychology, engineering and neuroscience and using these fields of study as insights for the application of theoretical solutions that will make the end product usable and useful for the user (Rogers, 2012, pp. 4–5).

In the present-day, Human-Computer Interaction is seen as a subsection of Interaction Design (IxD), being used interchangeably. HCI is seen as a tool for interaction design, sharing this characteristic with Visual Design, Cognitive Engineering, Computer-Supported Cooperative Work, et cetera (Rogers, 2012, pp. 2–3)

Within this dynamic HCI is used in IxD to inform the process of building a solution (Rogers, 2012, pp. 68–71).

HCI finds what are the capabilities and limitations of users, using concepts like Memory, Attention, Perception and Decision-Making (Rogers, 2012, pp. 21–22).

Being HCI integrated into IxD, looking into Interaction Design can give us a more complete image of the rules and heuristics and the relevance of the user in the process of building a solution.

In Interaction Design, the user is at the centre of all decisions and design choices. The goal of IxD is the development and design for user experiences that enhance and augment their everyday life (Sharp et al., 2019, pp. 9–14).

Having the user in the centre, IxD explores the three main elements that define how users interact and experience digital solutions. The three elements are Cognition, Emotion and Motivation.

Cognition is understood as the process of acquisition, gathering, transformation and recovery of information. It involves mental dynamics and mechanisms like attention, perception, memory, learning, problem-solving and decision-making. When interacting with software, cognitive processes are how users understand and operate the interface (Sharp et al., 2019, pp. 102–103).

Understanding cognition, in Interaction Design, allows us to infer user limitations, foresee user behaviour within the digital solution structure and interactions and interpret difficulties and challenges encountered by the users.

> The study of human cognition can help us understand the impact of multitasking on human behavior. It can also provide insights into other types of digital behaviors, such as decision-making, searching, and designing when using computer technologies by examining human abilities and limitations.
> (Sharp et al., 2019, pp. 102–103).

Emotions are the elemental aspect that outlines the quality of the user experience (Sharp et al., 2019, p. 165).

In IxD understanding emotions and their origin (what gives positive and negative feelings to the user and when the user expects to feel the specific emotions) is key to defining paths and flows of interactions that will lead to a good user experience (Sharp et al., 2019, pp. 166–167).

Last, Motivation is what informs, in Interaction Design, what the user wants to accomplish with our digital solution.

Understanding user motivation and goals allows us to deconstruct and foresee user behaviour.

Not only in Human-Computer Interaction but also in Interaction Design, the theoretical basis is understood to be applied to digital solutions regardless of the medium used. This means that the concepts, laws and heuristics found in HCI and IxD are transferable to virtual reality solutions and essential for the creation of a good VR user experience with usability in mind.

Usability is a measure of how easy it is for users to use a product, service, or system to achieve their goals. It is an important factor in the design and development of any product or service, as it determines how well users can accomplish their tasks and how satisfied they are with

the process (Nielsen, 1993, pp. 23–24). If we understand Virtual Reality as a means of communication with the user, usability is what gives the measure of the effectiveness of communication from the digital experience to the user (Jerald, 2016, pp. 53–54).

To understand the applicability of these concepts in virtual reality the way users gather information, process it and respond to its needs to be conceptualised.

In Virtual Reality, we can break down user's perceptual modalities into three elements, Visual Modalities, Auditory Modalities and Physical Modalities.

Visual modality focuses on what the user can perceive with sight. The visual modality is where we see elements like text, user interface, 3d models and animations.

Figure 3 - UI concept for VR game Store using Visual modalities.

The visual aspect of perception is a dominant feature in most of the nowadays digital solutions, like smartphone apps, and is the most discussed and theorised in Human-Computer Interaction and Interaction Design (Pangilinan et al., 2019, pp. 14–15).

The visual modality stands out because of the versatility it portrays. Visual elements are easily understood by the user and are not Time-dependent being capable of being spatially static, this means, the element can be kept *ad infinitum* in the interface. Not only that but visual elements are easier to rearrange without losing user understanding (Pangilinan et al., 2019, pp. 14–15).

For the adoption of the visual element, the digital solution needs a visual interface, like a tv screen or a touch-sensitive screen. In the case of virtual reality, the common interface is the Head-Mounted Display (Pangilinan et al., 2019, p. 15).

When designing visual elements for virtual reality, in contrast with conventional interfaces, we need to focus on more complex concepts around user characteristics and behaviours. The reason for that requirement is the nature of a virtual reality solution. In Virtual Reality, the user has a more visceral interaction with the software (Jerald, 2016, pp. 85–87), being immersed in the virtual reality environment.

Immersion in VR refers to the extent to which a user feels completely absorbed and engaged in a digital environment created by a VR system. It's the sensation of being physically present in a computer-generated world, even though the physical surroundings are still the real world.

> Immersion is a description of a technology, and describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant. (Slater & Wilbur, 1997)

The user interacts with the environment using a full range of motions and is able to see a high level of information in the 3d space. The point of view of the user is in the first-person perspective. For this reason, the stability of the information spectrum is easily undermined. When designing for virtual reality most of the decision-making is more kin to architecture and interior design than to conventional flat UI design.

Some of the visual concepts applied in virtual reality are Field-of-view, eye movement, peripheral vision, perspective and distance. Understanding the application of these concepts is essential for the development of more immersive experiences (Jerald, 2016, pp. 90–99).

One of the visual concepts introduced by video games and essential for Virtual Reality is the notion of location (Pangilinan et al., 2019, p. 20).

In a simulated reality, a user can travel in space. For that reason, conventional rules of the hierarchy of information are harder to grasp.

Some of the techniques used to solve the hierarchy involve the relation between types of UI.

There are four types of user interfaces applied in 3d spaces, Non-Diegetic or conventional UI, Diegetic UI, Meta and Spatial UI.

This division of UI types is made taking into account the relation of the UI with the User and with the virtual space.

Non-diegetic UI can be understood as the most "unnatural" type of User Interface. Unnatural in the sense that it doesn't rely on organic and realistic forms of communication, using instead symbols, perfect shapes and text.

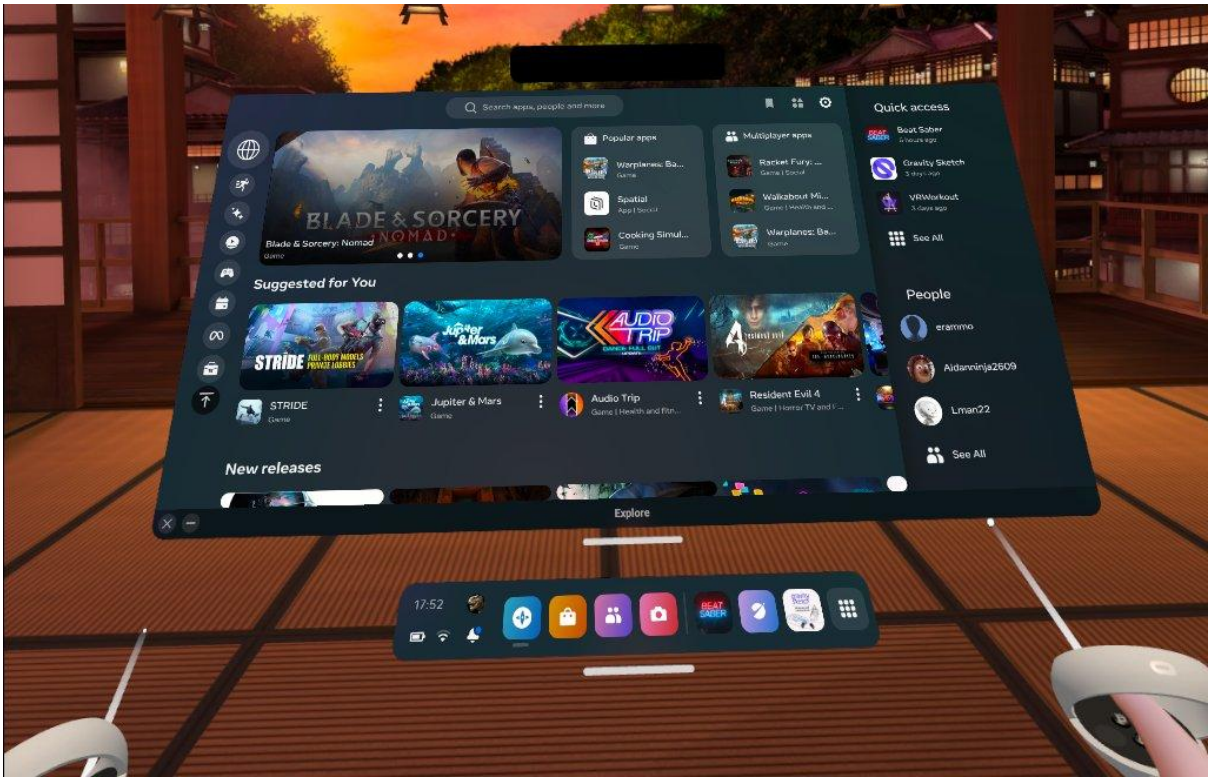

Figure 4 - Meta Quest 2 Main UI using non-diegetic elements.

Non-diegetic UI is the dominant type of interface used in most of today's digital solutions. Most of the visual components and elements used in Design Systems are non-diegetic, relying on colour hierarchy, geometric features and alignment to get through the user's perception and emotions.

In Virtual Reality, Non-Diegetic UI is used mostly as a neutral interface. It is used to make simple menus, where the message is mostly functional and Head-up Displays (HUD) to present the user with complementary information about the VR experience.

The use of Non-Diegetic UI in VR is convenient and useful because it gives the VR solution a level of consistency and connection to other conventional digital solutions, making the interaction easier to understand by the user.

The reverse of Non-Diegetic UI is Diegetic UI.

Diegetic UI is when the interaction mechanism mimics the same visual characteristic from real life.

Videogames are where we can observe most of the Diegetic UI in use. One example of the application of Diegetic UI is in the game developed by 343 Industries called Halo 4. In the game, the player, instead of seeing the bullet counter in the non-diegetic HUD, the information is presented in the virtual weapon as would be expected in real life.

Figure 5 - Halo 4 uses Diegetic element to represent the number of bullets in the active weapon. (Steam, 2023)

For Virtual Reality, Diegetic UI elements are a fundamental piece. With the use of Diegetic UI, the level of immersion in the experience is higher. The use of diegetic UI in VR can give to the user a better connection and sense of realness to the experience.

One of the negative aspects of Diegetic UI is the effectiveness of communication. In the example above, from Halo 4, the information the game designer is trying to transmit is simple enough not to be an inconvenience but, if we try to do all visual communication in a diegetic form, the information will clutter itself and the user will be unable to function within the solution, affecting the usability and user experience.

One of the solutions found to the problem above is a hybrid between Diegetic and Non-Diegetic UI, called Spatial UI.

Spatial UI is defined by visual elements that aid the communication with the user, using Non-diegetic characteristics but inserted in the Diegetic or Virtual World.

Some examples of the use of Spatial UI can be seen already applied in Virtual Reality.

In the Meta Quest Headset, there's a safety feature called Guardian. This feature is used to delimit the boundaries of locations the user can move to without putting himself in danger. In the VR experience, these boundaries are represented with a halo wall overlaying the virtual world.[3]

This type of solution is more effective than diegetic UI but can allow more immersive than Non-diegetic UI.

This type of visual element can be seen applied also in Augmented Reality solutions.

The last type of visual user interface is Meta UI.

Being Diegetic the opposite of Non-Diegetic UI, Meta will be the reverse of Spatial UI.

In this type of UI, the elements will have the characteristics of Diegetic UI but will share the same space as Non-Diegetic UI.

The DuckDuckGo app for Android has a feature that closes all browser windows instantly, the Fire Button. When the user clicks on the fire button an animation of diegetic fire will appear on the screen, overlaying the actual app, representing the erasing of the browser windows.

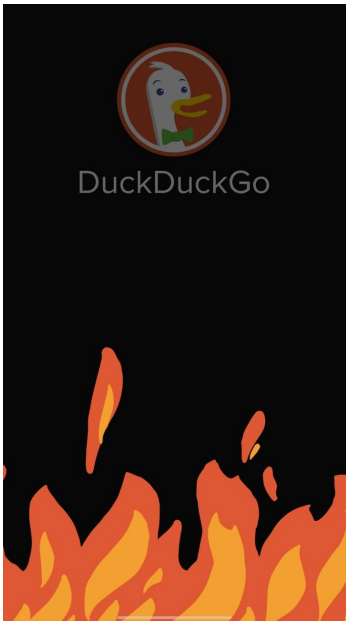

Figure 6 - DuckDuckgo App Meta Ui for the Fire Button.

[3] See Figure 2

In the case of Virtual Reality, we can see Meta UI applied in the physics/Shooter game BoneLab. When the player dies, instead of a splash screen, the user sees a tunnel effect, similar to the turning off of an old analogue TV.

The advantage of using Meta UI in VR is the fact that we can inform users about things that normally break the immersion of the experience, like dying in-game, but keep the immersion by using the same diegetic language applied in the experience.

In VR, in opposition to conventional UI, but in similarity to Videogames, the solution can also rely on Auditory modalities.

Auditory modalities are defined by audio elements like music, sound effects and voices that are used to communicate and interact with the user (Pangilinan et al., 2019, p. 14)

The use of sound in VR has advantages. With sound, the user can deduce particular characteristics of the environment. If the user is in a small or big virtual room, the sound of stepping can give a clue of the type of floor the user is on, the heaviness or lightness of sounds aids with the understanding of the things around the user. (Jerald, 2016, p. 99)

Sound as an interaction and communication mechanism in Virtual Reality can be easily used as a support for visual modalities. If we want to make the user look beyond their field of view, moving their eyes and head, the use of stereo or surround sounds can guide the user to where we want them to look (Pangilinan et al., 2019, pp. 16–18). The use of Sound can also help reduce visual overstimulation, making the VR solution more usable and accessible.

> A utilização do som como interface reduz a sobrecarga visual. Quando uma interface visual fica congestionada com grandes volumes de informação, o utilizador poderá ficar distraído. Esta sobrecarga visual pode ser reduzida utilizando o som como substituto da monitorização visual. (Silvestre, 2012, p. 15)[4]

[4] *English Translation using ChatGPT*

> *The use of sound as an interface reduces visual overload. When a visual interface becomes congested with large amounts of information, the user can become distracted. This visual overload can be diminished by employing sound as a substitute for visual monitoring. (Silvestre, 2012, p. 15)*

Not only that but the use of Diegetic sound can give the experience a visceral and natural essence aiding the immersion of the VR solution (Arnaldi et al., 2018, p. 23)

As an input method, sound can also enhance the Virtual Reality experience.

It can be used as a navigation system, that is, for example, the use of voice recognition to access interactions that are normally visual, allowing multitasking in the virtual environment (Dubois et al., 2010, pp. 149–150).

Auditory Modalities are normally used as secondary interaction modalities because of some of their characteristics. Sound is time-bound, meaning that if the user misses the audio cue, the cue needs to be repeated. It is also vague, being more open to subjectiveness than visual elements. From a development perspective, the sound is not as customizable as visual elements, being hard to iterate between different versions of the solution (Pangilinan et al., 2019, p. 17).

For these reasons, auditory modalities are not commonly used as a main way of communication but as an enhancer of visual interfaces and interactions, serving as an amplifier of immersion and aiding with the clarification of spatial-bound information hierarchy (Jerald, 2016, pp. 100–101).[5]

Physical Modalities are connected to the experience of touch.

With touch, we can access a lot of information. By processing vibration, temperature, texture and shapes with our receptors we can determine what we are touching and foresee the possible behaviour spectrum of the thing we're touching (Jerald, 2016, p. 103).

In digital solutions one of the most recognized physical modalities is haptics.

Haptics is defined by mechanical systems that make an object vibrate in certain frequencies. Smartphones use haptics to simulate the action of pushing keys. In video games haptics are used, with gamepads, to entail to the player information about the gameplay, Bashing into a wall with a car in a videogame can produce a high-intensity, short-term haptic response. In parallel, sky-diving in a videogame can give a gradually higher-intensity, long-term haptic response representing the wind and the acceleration of the player's avatar into the ground (Donovan, 2010, pp. 265–166).

[5] Auditory modalities such as in-game voice chat on multiplayer games such as World of Warcraft have a prominent impact on the player experience. With In-game voice chat players can easily collaborate to achieve a specific game goal. This Auditory modality is also vital in Role-Playing Games for the immersion in the game universe (Bogdanov, 2022, pp. 5–6).

For VR Haptics are also the dominant solution for interaction. Being Virtual Reality focused on immersion, Haptics allow users to experience a deeper connection with the VR experience. Also, Haptics allow the mitigation of motion sickness, associating the visual motion with a physical reaction (Jerald, 2016, pp. 104–107).

They are used as an Immersion mechanism, mimicking the grasp of objects (Arnaldi et al., 2018, pp. 141–143).

Being capable of enhancing the immersion of the VR experience, Haptic technology encounters its share of challenges.

Compared with a realistic touch, haptics can only represent the action of touching, living between a binary system of touch. It lacks certain characteristics of real touch like temperature, shape, weight and texture. Not only that but the haptic response is constrained to the virtual object itself and not to the user, meaning that every time the user interacts with the object, the haptic response will be the same, regardless of the way the user interacts with it (Arnaldi et al., 2018, pp. 141–143).

There are some hardware alternatives to Haptics in VR. We have 360-degree treadmills that are used to represent not only movement in the virtual world but also ground characteristics like the floor angle, tools that simulate rain, and temperature shifts and even sensors that use real objects as a physical modality for virtual objects.

The problem with this kind of solution is its cost-efficiency. Most of these systems are inaccessible to users, being only used in lab situations and recreational venues. This means that for a Designer or Developer, creating physical modalities for these systems is directed at a very small niche of users(Arnaldi et al., 2018, pp. 146–147).

To surpass the temporary unrealism of haptics some software use less diegetic physical modalities.

Beat Saber is one example. Beat Saber is a fast-paced rhythm game that relies on quick movements from the user. The user's goal is to cut blocks using the rhythm and sounds of music. In this game, when the user cuts through a block it receives a haptic response. These responses, although unrealistic, help the immersion of the experience because it expands the player's perception beyond the visual boundaries. Not only that but it is also a very effective way of transmitting to the user if it was able to complete the interaction with the cube or if it failed.

Looking into the Interaction Modalities we can understand the richness of interaction mechanisms that can be developed for VR. To be able to explore these possibilities we need to understand the Design and Decision Process for Virtual Reality.

Case Studies

Understanding the concepts of Human-Computer Interaction, Interaction Design, the user perspective and experience and the modalities associated with the interface can guide us to the development of the VR solution proposed in this project. Knowing the complexity of these concepts and how they define the quality of the digital solution also put in perspective the level of intricacy and organisation needed.

For that reason, the exploration of already applied Design Systems for Virtual Reality is an essential part of this project.

Two of the dominant companies in the Virtual Reality Marketplace are Google, with the AR/VR and Cardboard project, and Meta, with the Oculus acquisition and the company's goal of the development of a Metaverse.

The development of Virtual Reality solutions within Google has stalled since 2021 mainly because of the lack of active users and interest from other app developers, but all the findings within the development stage of Google's VR solutions are freely accessible on the Internet and with the Video Recording of Google I/O Virtual Reality Presentations.

The main focus of the Google AR/VR project was the investigation and documentation of findings, insights and design strategies for Virtual Reality.

It was a multidisciplinary project, crossing areas like user research, Interaction Design, 3d Art, Sound Design, Visual Design, Environment Design and Game Design (Google, 2022).

For the development of solutions, it was used two known design processes, SPRINT and IDEO.

SPRINT is a design process that is part of the SCRUM product development process mostly used in Game Development and Game/Design Jams as a fast pipeline from ideation to a Full Product or a Minimum Viable Product (MVP) (International Scrum Institute, 2023).

It consists of different stages of a fast design process (can be a day, a weekend, a full week or a full month) that feed each other data and insights until it reaches an end product.

The process starts with two meetings, one where it is defined *what* the project consists of and another meeting where it is idealised *how* the project will be built. It will be defined by these two meetings' insights the user flows, personas, goals and tasks for the project. These two Initial

meetings are also where the Team is split into smaller groups that will focus on smaller and more detailed tasks.

The next stage is Implementation, where the different members will develop their solutions for the tasks formerly defined.

Sometimes there are midway implementation meetings to share findings and insights with the whole team and to ensure consistency within the project.

The final Stages are the Sprint Review and Sprint Retrospective Meetings. In the first, the goal is to complete and implement the solutions developed in the Sprint process and in the second the goal is to document and discuss all the findings, failures and changes that will feed information for the next Sprint (Google Developers, 2016; International Scrum Institute, 2023).

In the Google VR/AR project the Sprint Process is used as a tool to find, explore and document new possible solutions or insights for Virtual Reality development.

The Sprint process in Google consists of a SCRUM Master and teams of one developer and one designer and the process is used not to end up with a full-blown solution but to discover opportunities for development and insights that will help the development of complete VR experiences (Google Developers, 2016).

For the Development of full XR solutions, Google's Strategy is the use of a product-oriented design process similar to the IDEO Design Process.

IDEO is a design and Innovation company that developed a human-centred design process, with a basis in Nielsen's Heuristics and Norman's Design insights, that uses divergent and convergent thought and design exercises to find and implement solutions (IDEO, 2023).

The process consists of three stages, Inspiration, Ideation and Implementation.

The Inspiration stage is composed of divergent design exercises that will help the design team to understand the client, and the users, explore already implemented solutions and brainstorm their own solutions (IDEO, 2023).

In Google AR/VR project the inspiration stage is where UX research starts and also where the insights found in the Sprint process results will be explored (Google, 2022).

The Ideation stage is where we start changing our mindset into a convergent state, where we start making design decisions. Normally here is where we find exercises like user flows, personas, low-fidelity wireframes, first usability and sitemap testing and so on (IDEO, 2023).

For Google's team, this stage is where Interaction Design, environment design, visual design, level design and prototyping start, accompanied by UX research results and is here where we can find some of the chosen solutions from Sprint, in a low-fidelity way (Google Developers, 2016).

The last IDEO process stage is the Implementation. In Implementation, the goal is to refine the solution into an end product. Visual and Brand Identity are applied in the high-fidelity prototypes. The Sitemap and Breadboard developed is fully applied in the High-fidelity prototype, A/B testing and usability tests are repeated to find insights about the high-fidelity prototype. This stage ends with the Developer's Handoff (IDEO, 2023).

For Google's Team, this last stage is similar to the Game Design process and Audiovisual post-production. The Development work is being done at the same time Designers are refining the high-fidelity prototypes and UX researchers are doing user tests. Sound Design, Motion Design, and 3d Art are also making and implementing assets (Google Developers, 2016).

Google's way of designing Virtual Reality solutions ends up being a hybrid between Product Design and Game Design. Google AR/VR team uses product design processes to structure the workflow and product pipeline but the Team elements are kin to a Game Studio Team.

If we look into Meta/Oculus solution we can find a very similar mindset.

In comparison with Google, Meta/Oculus have their focus, not on the development of VR solutions, but as an intermediary for Virtual Reality experiences. Their main solutions are platforms for other Virtual Reality solutions and tools for development and collaboration (Brady & Emms, 2015).

However, it's worth noting that the approach Meta/Oculus takes in structuring the development of these tools and platforms isn't significantly distinct from Google's strategy.

They also rely on Sprint as a way to test and explore their own solutions and use a design pipeline similar to IDEO (Brady & Emms, 2015).

Knowing that the process by itself is similar to Google's we can understand the reliability that the application of Sprint and IDEO have for the XR Design Process.

Being focused on platforms and tools, Meta/Oculus process can also give us some relevant design insights.

The nature of the solutions developed by Meta/Oculus required a higher level of UI complexity. For that reason, immersion is not the main focus of development but the usability of the tools developed. Keeping that in mind Meta/Oculus apps use mostly projected non-diegetic 2D UI.

Being the UI non-diegetic, and primarily 2D, using only parallax as a way to deliver a higher level of Immersion, the solutions and rules applied for the design process are kin to the web/mobile product design.

This means that, for Meta/Oculus, designers use design and prototype tools like Figma or Adobe XD for the first stages of development. This takes some of the design process complexity making the development easier to iterate (Jerald, 2016, pp. 401–406).

After the development of flat UI, designers will implement their work in a 3D environment, using tools like ShapesXR and Meta Horizons.

Separating the design process into these two stages, 2D design and 3D implementation can help the development team because it makes it easier to iterate and test design decisions (Jerald, 2016, pp. 401–406).

The drawback of this strategy is that is only efficient for Non-Diegetic UI because is not necessarily dependent on immersion, but when looking into Spatial and Diegetic UI, testing in 2D will never inform us about the immersive experience expected from this type of UI (Jerald, 2016, pp. 421–424).

Taking that into account Meta/Oculus strategy can be adapted into testing and iterating immersive UI. Using tools like ShapesXR and Meta Horizons instead of Game Engines to discover user insights in the Low-Fidelity stage can make the ideation process faster and easier for the Development Team (Brady & Emms, 2015).

Understanding Google's and Meta/Oculus Design processes informs us about the methods and strategies to be taken in the project proposed. Crossing this information with the theoretical background explored gives us a starting point for the development of the Virtual Reality Solution.

Before starting the project itself we need to understand the object explored in the proposed solution.

Movement as means of Interaction

Choreographic Tools

With the intent of developing an exploration and choreographic tool using Virtual Reality, one of the relevant steps needed is the understanding of Exploratory and Choreographic Tools.

Exploration is a term used in Dance as a way to represent the dancer's internal research for movement solutions, using sensations, spatial and time perception, and motricity. Normally associated with Improvisation, it goes beyond that (Lepkoff, 1999).

A Dancer is always in a state of exploration, finding new dynamics for any given movement or sequence. Being alive, and so dynamic in their physical, mental and emotional state the constant research mindset serves as the middleman between the projected movement and the actual movement made by the dancer (Blom & Chaplin, 1988, pp. 8–11).

Because of that every time, a dancer moves (or doesn't) there's an underlying state of research that gives the argument that all movement solutions are actually exploratory.

When talking about exploration tools or exercises we are not arguing that dancers are not exploring outside of these tools, but these tools are designed to enhance the Dancer's exploration.

In practical terms exploration tools try to take away from the dancer the movement solutions they normally rely on, forcing the dancer to explore new paths to reach similar or completely different possibilities.

One very known exploration tool is *Material for the Spine*, by Steve Paxton.

Material for the Spine bases itself on knowledge acquired by Paxton about movement efficiency and efficacy.

Using Martial Arts and Modern Dance background Steve Paxton designed a collection of guiding videos that use notions of gravity, relation with space and the floor, the natural spiral from the human body, the centrality of the Core and Spine as points of origin for movement and consciousness of the body in sight an out of sight to equip dancers with a vast range of new movement solutions (Bleeker, 2017, pp. 32–33).

This tool is centralised in a mirror-like approach, meaning that the movement is presented to the viewer concretely, with a real body doing the movement, instead of an abstract form factor.

Even though Paxton's videos use a concrete representation of movements the goal itself is not the mirroring of the movement by the viewer but the use of the video tool as a guideline, a point of guidance for the movement imagetic.

To aid in the construction of the mental image of the explored movement the tool also relies on the use of sound, like narration and diegetic sound of movement, and in the use of alternative points of view.

One example is the video entitled *Weight of Sensations* from the *Material for the Spine* subsection *Sensations and Senses*. Here the goal is the exploration of the relationship between our body and Gravity. The way the body adapts to the surface of contact, the energy the surface gives back to the body and the way we sense the surface (Paxton et al., 2008).

To create the imagetic associated with this relationship the video is shot in a worm's-eye view so we can see Steve Paxton's body as if we were the abstract concept of gravity. The video is shot with Paxton on a Glass-like surface so we can have a wide viewing angle and see the flattening of the body as it adjusts to the surface.

The use of this viewing angle is not replicable by the viewer, making it project the image into the relation it has to the floor, and forcing him into exploring the movement using this mental image.

The use of narration in Steve Paxton's Tool is not just a formal guide for the movement but also appeals to the internal sensations, making the dancer focus not on the movement's aesthetic and form but on how the movement feels.

As an exploration tool *Material for the Spine* defines good practices in the ways it communicates with the viewer, allowing the concrete image to be understood as an abstract exploration directive.

Movement Tools can also be focused on the creation of artistic work.

Choreography is understood as the design of logical movement sequences with artistic intent and perspective (Forsythe, 2019; Stumpp, 2017)

Choreographic creation is understood as the set of tools and processes a specific choreographer uses to compose and transmit their artistic message (Marques & Xavier, 2013).

Wayne McGregor is an English Choreographer recognized worldwide for his disruptive, innovative and research-based approach to movement. Working side by side with architects,

engineers, and neuroscientists he explores dance as a medium and sees movement as kinetic communication within the medium (Studio Wayne McGregor, 2023).

Following the research work made, for the development of the *Atomos* show, with the *Choreographic Thinking Tools,* a collaborative project between Wayne McGregor, his company Random Dance and Neuroscientists, it was created a Choreographic resource called *Mind and Movement* (Wellcome Collection, 2014).

Mind and Movement is a Choreographic tool that uses cards, imagery and text inputs to lead dancers and choreographers to explore and choreograph in a connected and abstract way.

Borrowing some of the structure from board games and social games, dancers are led to explore stimuli within their self-perception and background, leading different movement solutions to work in a connected way.

The tool explores vast concepts like Imagetic, the use of mental images as guides for the actions taken, and movement translation, the use of others' movements as points of structure for movement exploration.

Looking into the proposed VR solution we can draw parallels and differences with the Mind and Movement tool.

The tool has already pre-determined stimuli defined by Wayne McGregor's language.

For the VR solution the proposal is the creation of a blank canvas where the movement output is predetermined but the VR environment, by itself, doesn't serve as an input for movement.

The similarities begin when we go to the second step of the Virtual Reality tool. When a second user is using the environment manipulated by the first user they are relying upon the digital stimuli to create their movement. To do that, as in *Mind and Movement*, the second user is translating the digital output from the first user into their imagetic.

The creative pipeline created here would be keen on movement translation, where, although filtered by the VR environment, the second user would use the first user's movement projection as a guide to their movement exploration.

To understand the feasibility of the proposed Virtual Reality solution, an understanding of the relationship between Movement and Technology is needed.

Relationship between Movement and Technology

Exploring Choreographic and Exploration Tools is relevant as a guideline to understand the concept implementation into the project proposal. Being a solution based on an innovative and disruptive medium is important to understand the relationship Dance and Movement have with Technology.

Merce Cunningham was one of the pioneers of the use of technology and Movement.

Cunningham's work is known worldwide, not only for his disruption from modern, formatted and still aesthetically driven dance Techniques but for the use of innovative ways to present his artistic message and choreography (Elliot, 1991).

One of the tools pioneered by Merce Cunningham was the software *LifeForms,* developed by Credo Software.

Lifeforms is a computer animation program that uses perfect shapes to simulate the dancer's body, allowing the user to choreograph even impossible-to-replicate sequences of movement (Copeland, 2004, pp. 168–169).

Choreographers, using this tool could make low-fidelity iterations of their choreography, to be replicated by dancers or could be used to develop full digital choreographies, from different dance techniques (Dixon, 2007, pp. 184–186). Merce Cunningham explored the fusion of the two worlds with works like *Trackers* and *Biped* (Tércio, 2009a, pp. 64–65).

The research established with LifeForms was extremely relevant to the established artistic work we have today, which uses the digital medium, tracking, and animation, as complementary elements for Performance.

One of the examples of the implementation of concepts established by *LifeForms* is the *Swap-Project* by Rudolfo Quintas.

Swap Project is an ensemble of interactive multimedia installations within the Performance Art genre. The project involved the exploration of human-computer interaction and the feedback loop between the body, systems of tracking and the digital response from movement stimuli (Quintas, 2009, p. 101).

In *Swap-Project* Rudolfo Quintas explored the idea of gesture and movement as interfaces.

Going against the mainstream futurism concept of the renderization of the human body as obsolete, by technology, Quintas sees technology as an extension of the dancer's intention, and

emotional response, keeping in the human side of the relationship the power of decision (Quintas, 2009, pp. 108–109).

One of the complex questions explored by Quintas is the duality between the explicit message conveyed by movement (movement as a physical action with mathematical relations between points) and the implicit movement (the emotion and intention, the subjective experience) (Quintas, 2009, pp. 108–109).

The explicit message is easily explored, using tracking devices and cameras that mirror or extrapolate the movement into a binary system of outputs. The implicit message is harder to explore because the point of origin is the inner experience of the dancer.

With this notion in mind, technology was designed as a reader of human intention. To do that, Rudolfo Quintas, focuses on the exploration of gesture. Gesture displays the specific characteristics of each individual, being fully unique. The technological filter that would read the gesture needed to access and enhance these unique features to enable the person moving to communicate their subjective experience (Quintas, 2009, pp. 110–112).

To reach the exploration of subjective experience Quintas draws a parallel between the manipulation of digital space and physical space.

Looking into the physical space, without a living being intention, the space by itself doesn't conceive any message. In the same way, digital space, without intent, doesn't communicate anything.

For that reason, Quintas saw that the explicit message of movement used as a means of interaction with the digital space would always convey the implicit message into the digital output, the same way explicit movement in the physical space conveys subjective experiences (Quintas, 2009, pp. 110–115).

Quintas's work saw technology and dance relationship with a performative and artistic perspective.

Looking into pedagogy we can also learn about this relationship.

Near-contact Person-to-3D Character Dance Training is a paper released in 2021 that explores the use of Augmented and Virtual Reality solutions as a means to train Dancers (Kirakosian et al., 2021).

Being the paper centred on Training the focus of analysis for the proposed project is the solutions found for the interactivity in VR.

The solution developed in this paper was directed to Latin dance duets.

Users would interact with a virtual character that would replace the partner in the duet.

Using tracking mechanisms the virtual dancer would react and mirror the movements of the user (Kirakosian et al., 2021).

The solution found in this paper follows a diegetic way of representing movement, using a virtual human character as a means of interaction. For the practice of already defined patterns of movement, this application can fulfil the project's target goals. This means that this interaction solution can be useful for users who already know the movement language used and who are only exploring the movements delimited by the language (Kirakosian et al., 2021).

For the project proposed this type of solution is not adequate. Wanting to explore movements that are not bound to a choreographic language or Technique, using a mirror-like solution wouldn't empower users with an exploration tool but with a movement sequencer or an explicit digital translation system of the movement.

Having this idea in mind other solutions could be found that would serve as a better case study for the proposed project.

ReacTable is a real-time interaction music tool developed in 2003 by Sergi Jordà, Martin Kaltenbrunner, Günter Geiger and Marcos Alonso (Reactable, 2023).

It works by using a webcam that tracks user movements in a round table and a projector that projects a visual interface that serves as audio visualisation feedback (Jordà, 2017).

Figure 7 - ReacTable (Reactable Legacy, 2023)

Using cubes with specific iconography and hand movement users can create sounds, sequence them and layer different audio outputs in a way that enables the creation of musical pieces.

The tool was designed to be used by musicians and non-musicians using an easy-to-grasp interface that allows the exploration of sound from the get-go without a steep learning curve (Jordà, 2017).

Being made for musicians and non-musicians alike, and being a real-time interaction solution, capable of being a music improvisation tool it's possible to see parallels with the proposed project.

One of the important takes is the language of interaction used in *ReacTable*.

ReacTable uses a simplistic language for interaction, using visually easy-to-understand UI.

Not only that, but the solution works without any preparation, allowing the use of any gesture to produce audible results. That allows the exploration and understanding of the tool to be made easier by the user (Kaltenbrunner et al., 2006).

ReacTable also allows for collaborative space. Anyone can intervene using their gestures and objects in the ReacTable table, allowing the creation of call and improvisation, collective auditory layering and so on (Kaltenbrunner et al., 2006).

For the proposed project, ReacTable gives us some insights.

To allow the exploration of movements, disconnected from formal techniques, and closer to the subjective experience, the definition of a simplistic, easy-to-grasp language is a must.

To do that the definition of general movement qualities and the associated interactions outputs are necessary.

One of the most recognized frameworks in Dance, for movement characterization, is Laban Movement Analysis, also known as Labanotation, developed by Rudolf Laban in 1928 (Laban & Lawrence, 1979, p. XI–XII).

Rudolf Laban defined human movement into four main components: Weight, Space, Time and Flow (Laban & Lawrence, 1979, pp. 11–12).

Weight relates to the sense of heaviness inherent to the movement. It goes from Heavy movement, where the body language shows more signs of effort to Light movement, where the body appears moving without effort.

Space relates to the directionality of the movement. It's divided into Direct movement, where the distance between two points in the movement is the shortest and Indirect movement, where the route used to go from one point to another is more complex.

Time is about the acceleration in the movement. When movement is done, a high level of acceleration from point A to a high level of deceleration on point B is defined as Quick. When movement is done with constant velocity, without big changes in the acceleration, it is called Sustained.

At last, Flow is defined by the tension in the movement. When the movement is done in a precise and tense manner, is called Bound, and when the movement isn't restricted and lacks precision is defined as Free (Laban & Lawrence, 1979, pp. 14–24)

The components above are used in Dance Composition and analysis as a way to define and notate sequences of movements and associated dynamics.

Using the same tool as a base level to read a user's movement in VR could be the solution for *Nabia*.

Analysing the movement in real-time, with the tool, and defining interactions for the movement components and their specific spectrums can be the elemental factor to enable the use of movement as a means of interaction being the next step in the development of the proposed project.

Project Proposal

As defined in the introduction of the document, the goal of the project is the development of *Nabia*, a VR solution that uses Movement as a means of interaction, allowing users to explore movement and interact with the consequences of said movement, in a simulated reality.

As an end-product, the project is envisioned with a considerable collection of features. The ability to record movement sessions, and to transfer them to other people so they can interact with it, or just observe the virtual results of the movement section. The capability to work in an unsynchronized co-op type of pipeline, where a movement session is modified by a second person, and the result of that session is manipulated by a third person, and so on, giving dancers a creative way to develop choreographies. The possibility of live multiplayer sessions where all dancers can manipulate the environment, allows the VR solution to also be used as a space for group improvisation sessions. The ability to record not only movement results but also the movement itself, with the use of motion tracking devices. The possibility to explore complex movements, using jumps and floor movement, with a vast range of dynamics.

Knowing all the routes the full-fledged version of the VR solution can take is relevant for this project to define the Minimum Viable Product (MVP) expected to be developed.

One way to define the MVP is to understand the current hardware and software limitations of the project.

The Virtual Reality solution is envisioned to be implemented in the Oculus Quest 2 headset.

The Quest 2 headset offers some features that made it the best choice for this project. It is an easy setup headset, does not need external tracking sensors and is capable of working standalone, that is, without connection to a computer (Meta, 2023). It is relatively cheap hardware, in comparison with other headsets in the market (McMillan, 2023). Most Virtual Reality users are Quest 2 users, meaning that we have a substantial collection of online resources that will aid the project development (Alsop, 2023 & Mansoor, 2022).

Being the best option for this project, the Quest 2 is not without some caveats.

Being designed to be standalone, all motion tracking is captured by the headset itself. This feature offers more portability to the device but it also limits the movement tracking complexity for the VR Solution. The Quest 2 does not capture leg and torso movement, being only capable of tracking the head, hands and floor distance. This limitation is circumvented by the device, using the relative distance between the 3 points to assume the body movement.

Knowing this hardware limitation gives us some insights into the MVP. The project can only rely on upper body movement and the distance between the head and hands to the floor. This means that all interactions need to be designed only for these tracking points.

Taking into account Laban Movement Analysis and the Hardware we can understand that some of the movements' characteristics will be harder to track in the VR Solution.

Weight is a very visual and subjective aspect of movement. If we consider only the points between the head, hands and the floor, it is nearly impossible to distinguish the intentionality between light and heavy movement. A solution would be using buttons on the Quest 2 controllers as a non-diegetic way for the dancer to convey to the environment the weight of their movement. This solution is actually standard in some Virtual Reality apps, such as BoneLab, where, when the player wants to grab something, it needs to hold the grip button on the controller. The Grip button is a harder button to press, forcing the player to actually use the hand grip, being a good solution to simulate effort.

Flow is also difficult to implement in the VR Solution, as it is right now because it would need some kind of predictive system to differentiate bound movement from free. For the development after the Minimum Viable Project, this movement characteristic could be used for the unsynchronized co-op pipeline, as a way of manipulation between the recorded movement and the replication precision of the dancer experiencing the recorded session.

Space and Time are the easier movement characteristics to explore because they are simple to track.

For Space, we only need to define actions for each direction in the VR world and for Time we need to calculate movement acceleration to inform the software how the directional actions will be performed.

Another subject to take into account is the time and resources available for this project.

The project needed to be developed in less than six months and be developed mostly by one person, having fewer but well-defined features is the only way to ensure a high-quality result. Not only that but, because the project is taken from a designer perspective and not a developer perspective, fast but testable prototypes are more important than a refined end-product, for the MVP.

Keeping in mind all the points above, the Minimum Viable Product will be defined as a Virtual Reality Solution, where a person can experience their movement using their upper body.

Focused primarily on the exploratory side of the project, meaning that the MVP is not intended to be used as a choreographic tool, by itself, because it will not have recording capabilities, besides screen recording. The main goal of the MVP will be the exploration of movement interactions, in real-time, between the dancer and the virtual environment using Space, Time and Weight (in a non-diegetic way) movement characteristics.

To guide the development of the project, using the knowledge for design processes explored in the theoretical framework section it was designed as a process, inspired by the IDEO Framework, using some Game Design tools.

The process is divided into three sections, Inspiration, Ideation and Implementation.

In the Inspiration phase, the goal is to find standard practices from other VR solutions and to understand the expectancies, struggles and desires of potential users.

For the first part, it will be made a Competitive Analysis, using some of the info found in the Theoretical Framework and Movement as a means of Interaction and some information found in known Virtual Reality products that share directly or indirectly, some similarities with the proposed solution.

For the second part, a user exploration session will be used, called Movement Workshop, to replicate some of the possible interactions to be implemented, using an already-developed external software. After the session insights will be gathered using questionnaires.

The Ideation phase is where the design and development of the software will begin.

In this section, the goal is to define and test interactions. To do that an Interaction Breadboard will be made, using the ShapesXR tool.

The first prototypes will also be developed in this phase, using Unity and ShapesXR, and will be subject to User Testing.

The focus of this section will be primarily on the user experience.

The final phase will be the Implementation phase. Here the goal is to join both visual and functional parts of the project, using the insights found in the ideation phase.

This section is dedicated mainly to the development of the Minimum Viable Product, but it will also consist of user testing, so we can find insights for the next steps after the MVP.

In this section the visual part will be implemented, using a Moodboard to develop assets for the project. Reaching the end of the proposed process the goal will be to have a Virtual Reality solution as a proof-of-concept for further development.

Project Development

Inspiration

For this project, the Inspiration phase will be divided into two parts.

Competitive analysis, where the objective is to understand how similar Virtual Reality software solved their user interactions and Movement Workshop, a user test with features akin to the ones found in Dance creative process.

Knowing that some of the common practices for Virtual Reality and other digital solutions were already explored in previous sections, but in a more theoretical framework, in the Competitive Analysis, there will be a more practical approach. This means that the software selected for the competitive analysis will be explored by using the software and not relying purely on third-person perspectives.

The selected software for the competitive analysis will be *BeatSaber, Liminal* and *OpenBrush.*

BeatSaber is a fast-paced rhythm VR game where players need to slash incoming blocks, using a virtual sabre, following a music rhythm.

Beatsaber has a very large VR community and it is a reference in the Virtual Reality industry.

The main reason why *BeatSaber* was chosen for the competitive analysis was that, although a rhythm game, it has a very strong dance influence on the way players interact.

With the main goal of slashing blocks in a specific time and direction, *BeatSaber* leads the player, indirectly, to perform choreography, that is, to follow a logical sequence of movements that has an intent, in this case, defined by the level designer.

For this reason, a big part of *BeatSaber* content creators centralise their content, not in outperforming other players, but in performing an aesthetic and structured choreography, using the game as the base for their movement structure (Beck, 2018).

This last point is relevant to the proposed project. Studying *BeatSaber* interactions and how they can lead to movement can establish solutions for the proposed VR Solution.

It is also important to disclaim that, apart from the similarity, in a generic view, between *BeatSaber* and the proposed VR solution, the former explores movement in an indirect but structured way, forcing players into specific movement characteristics and the latter intends to explore movement directly but in an unstructured way that allows movement exploration.

In BeatSaber, music follows a dominant guide for interactions. Being a rhythm game, the goal of the user is, in a simplistic form, to replicate the rhythm and nuances from music. That means that users are not compelled to dance, and can play using direct and minimalistic movement.

Being able to play in that manner, *BeatSaber* uses some strategies to circumvent this limitation and to induce users to dance, being one of the strategies, music itself.

In all different levels in BeatSaber, not all beats in the music are used for interactions. These blank spaces in levels feel unnatural for users because the established interaction language leads users to believe that there should be some kind of interaction at that moment. Because of that users tend to fill in the blank areas in their own movement. The relation between the blank spaces' movement and specific game interactions forms a choreographic sequence, allowing the user to dance while playing.

This strategy is similar to the one used in contact improvisation jams. In Contact Jams, organisers are responsible for leading the flow of the jam. For that, they use music as a way to give dancers guidelines for their movement. The relation between music's inspiration and the dynamics of contact improvisation appeals to the enhanced diversity of movement and dynamics in the session.

With this in mind, it is easy to understand the potential of the use of music in *Nabia*.

Another strategy used in *BeatSaber* is in the sequence of interactions.

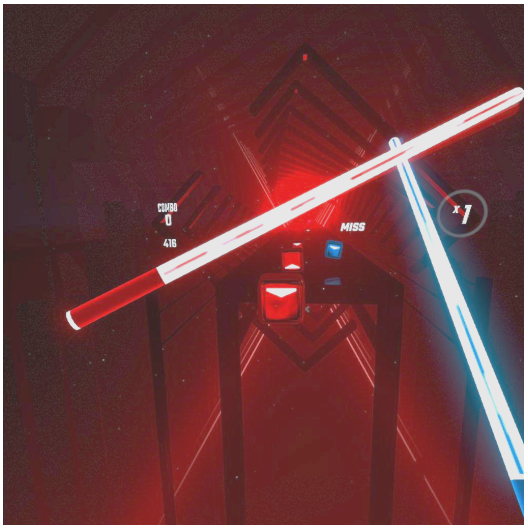

Figure 8 - BeatSaber

Instead of following a symmetric approach, in *BeatSaber,* interaction tends to follow an asymmetric, and dynamic flow. The left and right hands have specific interactions that can follow

different rhythms and qualities of movement. The complexity of interaction sequences in *BeatSaber* leads users to explore the spectrum of directions, heaviness of movement and intentionality.

This exploration of movement is keen to the one intended to be explored in the proposed VR solution.

In *BeatSaber*'s case the solution follows a direct and choreographed approach, but wanting to build the solution as an exploratory and choreographic tool this strategy would be a limiting factor.

But if we take the idea of asymmetry between different parts of the moving body as different points of interaction, there's a potential to build an interaction language that will convey users into exploring a wider spectrum of movement qualities.

Another Virtual Reality solution analysed here is *Liminal*.

Liminal is designed as a platform for VR experiences. In this software, users can choose to try different VR environments and experiences, designed for a wide variety of emotional states.

The app is currently divided into 4 sections, *Energy*, *Calm*, *Awe* and *Pain Relief*, each with different sets of experiences designed to entail to users certain emotions and to lead them into movements and experiential moments (Liminal, 2023).

Liminal was chosen for the competitive analysis because of two main reasons. First because of the visual communication of the app, the UI, and second because of the way it tries to guide users in an indirect and subjective approach.

Liminal uses a diegetic but abstract UI. The Menu is represented as a set of light doors in an infinite and liminal space.

Figure 9 - Liminal Diagetic UI

To interact, the user, uses two different types of UI. For functional interactions, most of the UI is more conventional, with non-diegetic UI, but inside the experiences themselves the UI explores a wide variety of Diegetic and spatial and Meta UI.

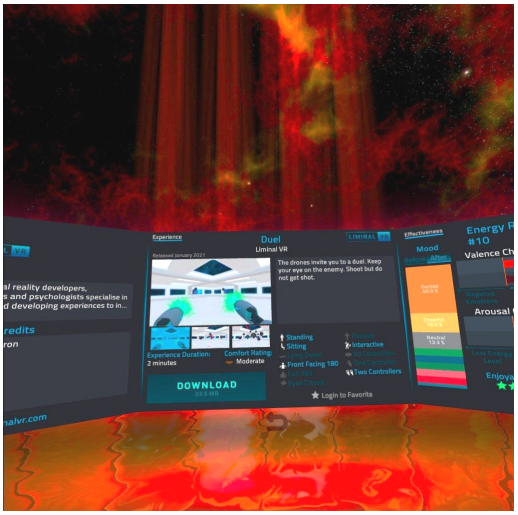

Figure 10 - Liminal non-diegetic UI

This design framework, functional actions with non-diegetic UI, and main and experiential interactions with Diegetic, spatial and meta UI enhance the immersion in the software experience enabling the user to experience the virtual environment with a higher sense of "realness".

The proposed project seeks to guide users into a similar immersion, and for that reason, the UI in *Liminal* is an inspiration for the environment development of the MVP and furthermore a reference for the development of a possible interface.

The main goal of the *Liminal* software is to address thematics such as wellness, emotional balance and good body-mind relation. Therefore, emotions represent a main influence in the development of the app experiences.

Using quizzes about user emotions before and after the user plays the chosen experience enables the development and fine-tuning of the experience itself.

In the experience itself, despite the wide variety of experiences in *Liminal,* most use indirect ways to guide the user. Using sound, colours and alternate means of interaction, such as the position of the head the virtual reality environment leads users into emotional experiences.

In Liminal the goal is to lead users into specific emotions. In the proposed VR project the goal is to lead users into exploring their movement.

For that reason, the indirect strategies and interactions explored in *Liminal* can be transposed into the proposed project to guide users into exploration.

The main difference between the *Liminal* case and *Nabia* is that in the first, the experience is designed with a beginning and an end, this is, a well-designed path for the user experience. In the case of the proposed project, the experience is designed to be fully malleable by the user, without any designed constraints, enabling users to experience the environment and their movement *ad infinitum.*

In *Liminal* there's a specific experience worth adding to the analysis called *Magic Wand.*

Magic Wand is an experience inserted in the *Pain Relief* section, with the goal of expanding the user's range of movement.

To reach this goal the user experiences an interactive 10-minute audiovisual experience.

The user has a virtual wand. With that wand, the user can manipulate certain aspects of the experience, the colours, the music tempo and pitch and the speed of the moving elements. To do that, the user needs to move the wand in all directions, in all levels of movement and with different rhythms.

In this experience, the manipulation made by the user can't change the experience itself, but only certain aspects of it. The solutions found for each movement characteristic can serve as a reference to define the proposed project interactions.

In one specific part of the experience, the size of the elements in the VR environment would change depending on the height the wand is positioned. In another moment the movement acceleration would move the dynamic elements around the user.

These are all examples of interactions that can be transposed into the proposed project.

The last Virtual reality solution analysed was *OpenBrush.*

OpenBrush is an Art software that seeks to bring the notions of visual art like sculpture and painting into the Virtual Reality environment.

Based on Google's software *Tilt Brush*, *Open Brush* is an open-source solution developed by members of the Virtual Reality community.

In *Open Brush*, users can create their own static world using a preset of brushes, visual elements and so on.

There are two main reasons why *Open Brush* was chosen for this analysis. First, the fact that the software doesn't have specifically designed experiences, enabling users to develop and manipulate their virtual environment at will. The second reason is the way users interact with the world. Users use the controllers to draw in the 3d environment but need to use full-body motion to explore it, sharing in that way similarities with the proposed project.

Figure 11 - OpenBrush Environment, interaction and Menu

To allow users to explore their creativity there's a set of virtual environments they can be in. The most basic one is completely white, allowing a fully free creative process. There are also environments with stands and mannequins designed for users who want to design virtual elements for real life. Finally, there's an environment, with a day/night cycle that seeks to inspire users to create.

For Nabia a fully mono-colour environment would be desirable. On one hand, it would give users a space where all elements would be connected with their movement, but on the other hand, the potential interactions and inspiration elements would be reduced to a very simplistic and minimalistic visual result. This could actually restrain movement instead of enhancing it.

For that reason, the last environment in *Open Brush* would be a perfect candidate as a reference for the environment in the proposed project. An environment with enough elements would allow inspiration for the user and interaction possibilities but that would be abstract enough that the influence in the movement itself would be minimal.

The interaction mechanism in *Open Brush* depends only on directional movement and the result of the user movement results in a direct, static representation of the movement itself.

Despite this, the way the movement is registered, in the conceptual sense, entails a similar solution for the proposed project.

Using *Open Brush* as a reference for the functional aspect of the proposed project, in this way, was a must.

The *Open Brush* software also has the potential to be used in the proposed project process, mainly because is the only available software that can register user movements without restrictions.

Table 1 - Competitive Analysis chart for analyzed software

Characteristic	**BeatSaber**	**Liminal**	**OpenBrush**
1. Purpose and Focus	Fast-paced rhythm VR game	VR platform for diverse emotional states	VR art software for sculpture and painting
2. Community Involvement	Large VR community; influential in VR industry	Experiences developed by in-house developers, independent users, universities, and investigation teams	Developed by the VR community; open-source
3. Gameplay Mechanics	Rhythm-based block slashing game	Wide variety of emotional experiences	Art creation with brushes and tools
4. Influence on Movement	Indirectly encourages choreographed movement	Indirect, vague, and subjective approach to movement	Full hand tracking for environment exploration
5. User-Generated Content	Focus on aesthetic choreography by users	Generated by in-house developers, independent users, universities, and investigation teams	Freedom for users to create virtual worlds
6. Use of Music	Music guides interactions; users can play directly or dance	Music plays a significant role	Music is nonexistent, but brushes have an auditory representation when in use
7. Inspiration for Proposed VR	UI design, choreography, and emotions exploration	Emotions play a significant role in experience development	Colorful environment as a reference
8. Interaction Mechanism	Asymmetric, dynamic flow; complex interaction sequences	Indirect ways (sound, colors, head position) guide users	Direct static representation of movement
9. Reference for Proposed Project	Exploration of movement and UI design	Exploration of movement	Functional reference for unrestricted movement registration

After understanding some potential solutions that other virtual reality applications use to solve similar interactions to the ones found in the proposed project, the next step is to understand how users react to the proposed interactions.

For that, a user test session, called *Movement Workshop*, was developed with the intent of testing interactions that allow dancers to explore and choreograph their movements(Movement Workshop plan is presented in Appendix A).

The test consisted of 4 exercises, done in pairs, that tested not only the exploration of movement but also the interaction between two users in the VR environment. The test was designed to be used with a third-party virtual reality application already analysed in the competitive analysis, *Open Brush*.

After the practical aspect of the Movement Workshop, a set of questions was made for users to gather their experience and insights.

The Movement Workshop happened in two different settings, in-house and at the Higher School of Dance (ESD).

In the in-house setting, two users were planned to participate in the Movement workshop, one a Classic and Contemporary Dance Teacher and the other a former ESD student working on politics as a Dance Advocate. The former ESD student didn't attend the Movement Workshop. The Movement Workshop was adapted for the Dance Teacher to be done with myself.

In the Higher School of Dance, two users participated, both from the first year of the Dance Bachelor's Degree.

The first exercise, called *Moving and Drawing in 3D Space,* consisted of a solo free exploration of movement in the VR environment.

The user, during the exercise, could move freely, and register their movement in the vr environment whenever they desired.

The goal of this first exercise was twofold, first to familiarise the user with the virtual environment and second to understand the limitations of VR, in a fully exploratory movement session.

One of the expected outcomes of this exercise was the possible feeling of claustrophobia provoked by the heaviness of the headset, motion sickness and the lack of spatial orientation.

In the VR industry, motion sickness is a well-known problem that creates a barrier in the full adaptation of this fascinating technology. Motion sickness leads to nauseous feeling, dizziness, vomiting and cold sweats and can be dangerous in certain conditions, such as disorientation and vertigo. (Chattha et al., 2020)

Surprisingly, user feedback was contrary to the expected outcome.

Users felt an expanded spectrum of movement freedom. The immersion given by the VR headset allowed users to more easily break their movement loops, allowing them to explore beyond their comfort zone. One user said "rapidamente desconectei a minha mente das limitações do meu corpo"[6] (Interview notes are presented in Appendix B)

Figure 12 - User (Diogo) Exploring the VR Environment

[6] English Translation using ChatGPT - *rapidly disconnected my mind from the limits of my body*

For one user the fact that they could see their movement after doing it was also a plus because it gave them more power and energy to their flow, allowing movement imagetic cross with the VR environment (Interview notes are presented in Appendix C).

The common pain point[7] in this exercise was the hardware itself. Even though the immersion allowed a wide spectrum of exploration, when confronted with the limitations of the headset and controllers users felt a break from the immersion. The fact that they couldn't roll easily on the floor, and couldn't use their hands to support their weight were limiting factors for their movement.

Still, some users felt that these limitations could actually be a positive factor, leading their movement into new forms, adapted to the headset.

Users were asked to propose some solutions to these limitations and most agreed that, at this moment in time, a solution that could allow the same immersion given by the VR headset doesn't exist, and using image projection or an AR solution could allow more movement but would break the sense of immersion of the VR experience.

[7] "Pain Point" is a IxD jargon used to refer certain characteristics, elements of the UI that lead users into a negative experience. (Cooper et.al., 2014, p.84)

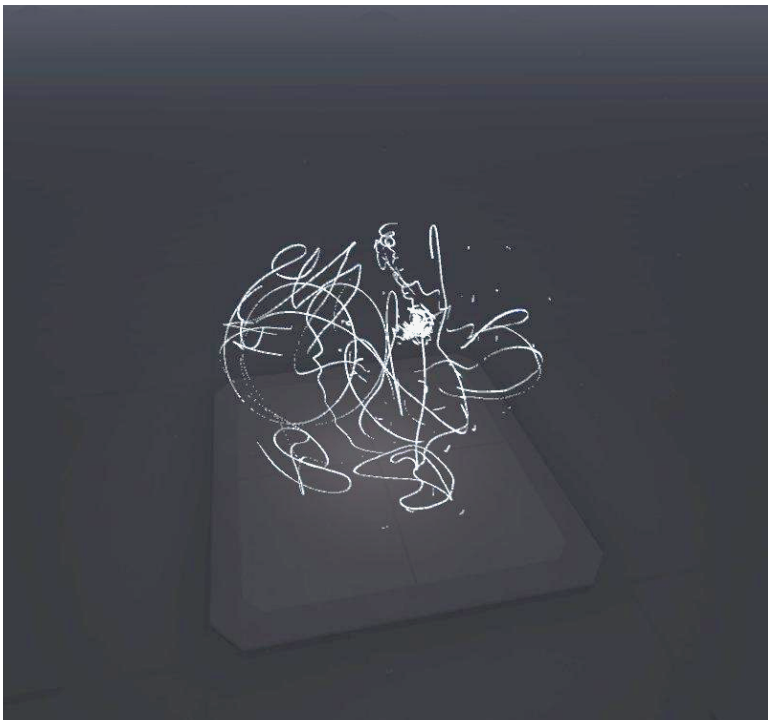

Figure 13 - Movement Workshop *Moving and Drawing in 3D Space* Exercise outcome

The second exercise is called *Projected Movement in the Environment.*

In this second exercise, the goal was to understand how a movement from one user, registered in the VR environment, could influence and lead the movement of another user.

To do the exercise, one user had an exploratory session in VR, without any limitations, similar to the first exercise.

When the first user finished the session, the registered movement was expanded into the boundaries of the VR environment. This time the second user would explore movement, without registering movement, but actually using the registered movement of the first user as an inspiration and guideline. Important to note that the second user wouldn't see the first user session.

This exercise allowed us to understand how the movement of the first user could influence the second user when the second user only had access to the virtual result of said movement.

Some of the strategies used by users were the use of the projected movement as trajectories for their movement, and the association of the projected movement with different parts of their body.

While exploring users felt the lack of dynamics. Open Brush being a Drawing app only allowed the collection of movement lines in a static format. Because of that users utilised the complexity or simplicity of the lines to create dynamics on their movement.

Figure 14 - Expanded movement in OpenBrush

This insight leads to the importance of dynamics in the proposed VR solution. Allowing users to be able to explore their movement in a dynamic fashion, where their movement fades away after being done, and their intensity is visible in the projected movement is a must.

Users also found potential for their creativity with this exercise. The transferability of one session to another person would allow the creation of a choreographic pipeline. Being able to connect the movement between two bodies without the bodies *per se* but with the outcome of their expression.

The third exercise is called *Dancer sees, Dancer moves.*

In this exercise, the goal was to test the dynamic aspect of the tool, which was impossible to evaluate in the previous test.

For this exercise, both users would be dancing at the same time, one with the headset, and another one with the controllers.

The user with the controllers would be fully improvising and recording their movement with the controllers, while the user with the headset would be using the lines of the first user as a starting point for their movement.

The big difference between this third test and the second test is the fact that the lines, for the user with the headset, appear dynamically, live, while they're dancing. This aspect seeks to mimic the behaviour expected for *Nabia*.

Most users felt a stronger connection to the movement of the second user, in comparison with the *Projected Movement in the Environment* exercise. Users pointed out that the fact that they could understand not only the direction but intensity and intentionality of the movement enabled them to explore more and connect with the VR environment (Interview Transcripts are presented in Appendix X).

One of the curious points in the user's insights was the understanding of the Virtual Reality environment as an entity. The dynamics of the movement mirrored the intentions of the second user but for the first user, who couldn't see the dancer's movements, the intentions were aggregated to the Virtual Reality environment. That made the experience feel like they were actually doing a duet with the environment and not only using the environment as a reference for their movement.

Users felt that the fact that the lines wouldn't fade out, similarly to the second exercise, would become overwhelming near the end of the exercise. The accumulation of lines in the environment was making it impossible to continue the connection with the movement of the first user. This insight reinforces the need to keep the movement registry dynamic, and time-bounded, for the proposed Virtual Reality solution.

The collaborative potential shown with this third exercise shows some similarities with the collaborative approach of the *ReacTable* solution (Kaltenbrunner et al., 2006). If instead of having a dominant dancer, registering their movement, and a compliant dancer, improvising with the movement of the dominant, having both the capability to register their movement, could lead to a more collaborative improvisation and choreographic session. This could be afterwards transposed into the real world, with choreography, or be used in Virtual Reality, using the dynamic environment as a standalone work of art.

The fourth and last exercise is called *Dancer sees, Dancer mirror.*

This exercise follows a very similar dynamic to the *Dancer sees, Dancer moves.* Both dancers participate simultaneously, one with the headset and the other with the controllers, but in this exercise, the dancer with the controller will try to follow the movement of the dancer with the headset.

The main goal of this exercise is to understand how it feels, to the dancer in the virtual environment, to see their movement being projected, in real-time, outside their sphere of movement.

Understanding how it feels can give some insights into the interactions for the proposed project.

Users at first, felt that the experience was uncanny. Partly because of the delay between their movements and the movement from the dancer with the controllers, users felt a disconnection between the environment and themselves and because their movement wasn't projected directly to the body parts that were moving but to the distant environment.

Afterwards, this feeling started fading away, when the users started to get familiar with the environment.

The familiarity with the virtual world and the relation with their movement led them to start feeling that the world was almost like a projection of their movement energy and not the movement itself.

This is a curious insight. The idea of projecting movement into the space, in Dance, is a very explored and used imagetic in contemporary post-modern dance techniques (Lepkoff, 1999, p. 4). The fact that the user experience mimicked that imagetic shows some ways that dance technique and Virtual Reality interactions can be crossed into an interaction language.

With this insight, for the proposed project, it is understandable how conventional imagetic in dance can be a leading factor in defining interactions in the virtual environment.

With the competitive analysis and the movement workshop, it was gathered a fair amount of insights, from industry-standard behaviours to the discernment of user experience, will be essential for the next step, the Ideation of the proposed project.

Ideation

The Ideation phase was split into two steps. The first step is the definition of the interactions that will be used in the proposed Minimum Viable Product, a static interaction breadboard and the second step is the development of said interactions into the Virtual Reality environment, a prototype.

To reach the end of this phase, two design and development software will be used: ShapesXR, for the interaction breadboard, and Unity Engine for the prototype.

Taking into account the insights and knowledge clustered with the inspiration phase and the Theoretical Framework and Movement as means of Interaction some guidelines were defined for *Nabia*'s interactions.

Bearing in mind that the Meta Quest 2 is limited to tracking only the hands and the head, all interactions were based on these three points.

Within the Virtual Reality environment, it is possible to capture different types of spatial movement and the relation between the 3 referred points using these movements.

It is possible to capture the vertical movement (y axis), the Lateral movement (x axis) and the depth movement (z axis) of all the points. It is also possible to capture the rotational movement of each point, but for the sake of simplicity of the proposed prototype, these movements were not used.

Looking into the possible movement tracking it is conceivable the use of them to build relations between the points. We can calculate the distance between points, the height of a point and the proximity of a point to the user centre.

All the interactions were designed within these possible movements and relations and implemented first into ShapesXR.

In ShapesXR it was built an interaction room with explanations and examples of the interactions to be implemented in the Prototype.

Taking into consideration the Laban Dance Composition components and the limitations referred to above it was designed to have seven interactions divided into three groups.

The first group has two equal interactions. In this group, we have the most standard type of interaction, the follow-path, that seeks to explore the space component, the user's movement directionality. This interaction is similar to the interaction in *OpenBrush*.

There is a permanent particle system fixed into the user's hands position. Contrary to OpenBrush in this interaction, the user can't choose if the interaction is active or not. The interaction is always in an active state. But in opposition to *OpenBrush* the particle system has a lifetime system, that is, the path resulting from the user movement disappears after a while. The goal of this decision is to follow one of the user's insights in the movement workshop and go against the excessive stimuli that were built up when using *OpenBrush*. Also, keeping in mind that these interactions are closer to the user's field of view, their temporary concept allows the user to focus on other interactions and not be overwhelmed with the follow-path. To allow the user to separate each movement result it was established that each hand needs to produce particles in a visually different way.

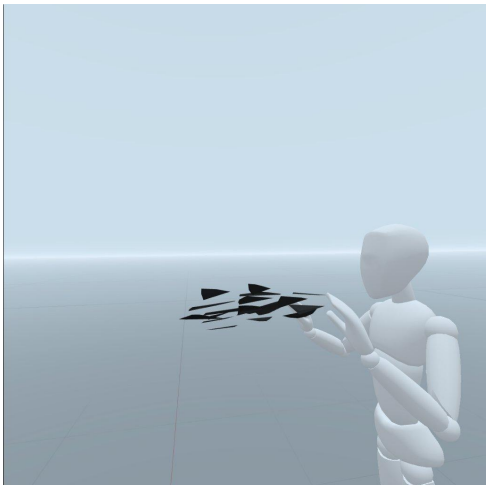

Figure 15 - ShapesXR Interaction Breadboard: Particle System

The second group comprises four interactions, two interaction types for each hand.

The first interaction type calculates the hand height using the body centre has the zero height reference point. After calculating the height the VR Environment uses the height value and transposes it into a VR element, changing their height in a linear manner. On one hand, it was established that it should move a low number of elements that are visually large and on the other hand it should move a high number of elements that are visually small.

The goal of using a linear movement translation rather than an exponential one is to follow the flow component. In this way, when the user wants to explore precise and bound movement, the movement result is as precise as the movement of the user.

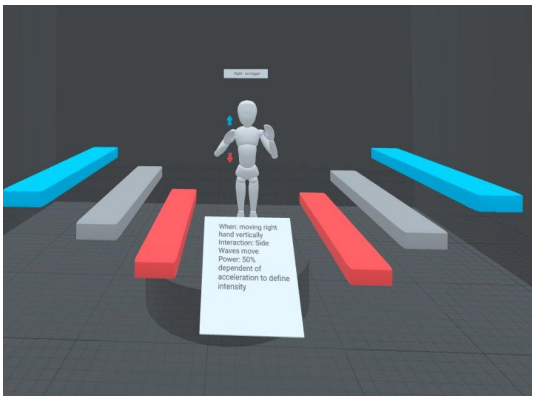

Figure 16 - ShapesXR Interaction Breadboard: Height Interaction

The second interaction type calculates the horizontal distance of the hands, using the body centre as the point of reference. In this interaction, all the points are defined as having the same zero height, so the height difference between the hands and the centre doesn't interfere with the interaction.

After calculating the distance the VR environment uses the value to establish the orbit translation and rotation of the objects being used in the interaction, in an exponential manner. To differentiate the movement resulting from each hand, one moves the objects to the left, and the other to the right.

In this case, it was used as an exponential factor instead of a linear one so the user can explore the weight component. When expanding the body extremities the movement tends to be more tense and heavy so the movement result needs to represent the energy being used by the user and not the distance itself.

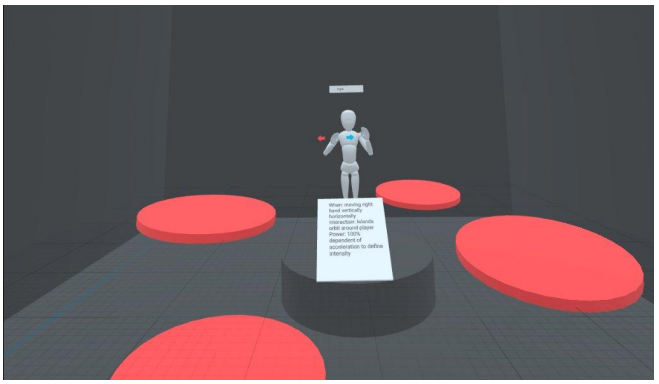

Figure 17 - ShapesXR Interaction Breadboard: Orbital Movement

The Last group of interactions is composed of one interaction.

In this group, the interaction seeks to calculate the distance between both hands taking into account all possible movement directions.

With the distance calculated the VR environment will move certain objects away from the user. The velocity of this movement is in relation to the distance calculated.

The goal here is also to explore the weight component in the user movement, and explore the time component in the VR environment.

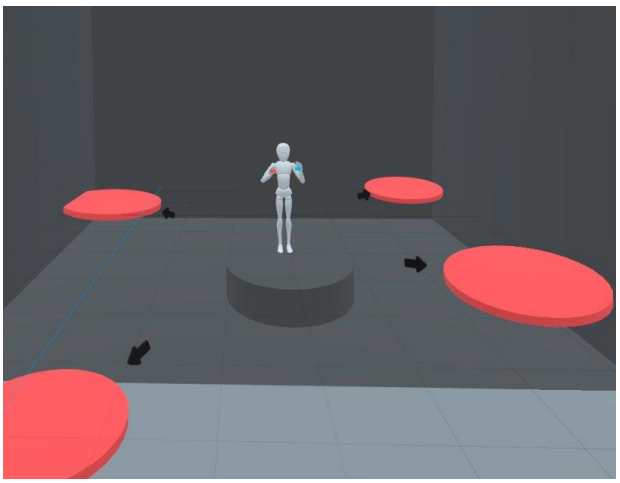

Figure 18 - ShapesXR Interaction Breadboard: Distance

With the interactions established in ShapesXR the next step was the implementation in the Unity Engine.

To be able to test each interaction it was built 4 prototype iterations, each more complex than the previous one.

The first iteration, here defined by prototype 0.1, focused on testing the feasibility of the interactions, out of the Virtual Reality environment. The goal was to simplify interactions in a way that allowed us to understand their behaviour on the game engine and to establish a baseline code for each interaction.

So, for the first iteration, the user would interact with the environment via the mouse, looking into the environment on the screen.

Knowing that interactions defined on the interaction breadboard on one hand have an almost equal counterpart on the other hand, in this interaction the focus was to develop a baseline capable of being copied and modified from one hand to the other.

In prototype 0.1 there were only two game objects, two spheres, to be manipulated by the user.

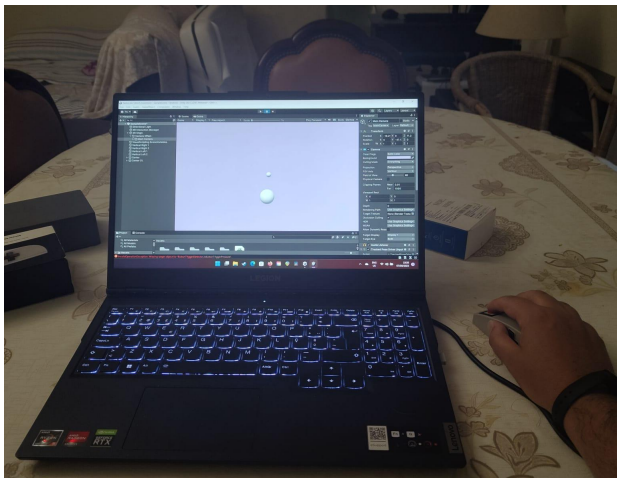

Figure 19 - Prototype 01 using the Mouse to control interactions

One sphere was horizontally locked, moving only up and down, in front of the user. With this game object the intention was to build the hand height interaction. The game object would move, in a linear manner, in relation to the mouse movement on the Y axis, that is, away or closer to the user.

The second sphere was orbitally locked to the player's point of view. With this game object two interactions were created. First with the mouse movement on the X axis, that is, side to side, the translation speed of the object would change in a linear manner. The second interaction used the mouse movement on the X axis to establish the orbit size, making the game object closer or farther away from the user.

With prototype 0.1 some insights were gathered.

The fact that the mouse position could be changed drastically made interactions easily surpass the expected reactions. If we moved the mouse too far the game objects would move away from the viewport or so far that would be impossible to see the object or so fast that it would be excessive stimuli for the user.

For that reason, a coded limitation was thought out to be implemented, where, after reaching a specific X and Y value, the rate of influence would decrease exponentially.

Another insight gathered in this prototype was how the coding part of the prototype would be handled.

In this iteration, most interactions were being coded purely in the main programming language used in Unity, C#. To ease the process of modifying the interaction and making adjustments the code was ported into Unity's visual scripting tool.

This way, not only modifications to the interaction were faster and easier to implement, the transferability of the interactions between game objects was easier.

After prototype 0.1 the second iteration intent was the implementation of the interactions from 0.1 into a Virtual Reality environment.

Being a direct transfer of interactions from the prototype 0.1 to the 0.2, in this iteration the environment manipulation was only made by one controller.

There were some key changes to the logic behind the interactions.

One of the insights acquired with prototype 0.2 was the redundancy of the limitations implemented on 0.1. When using the mouse to interact, the user is allowed to move it *ad infinitum*, and for that reason, the limitations were needed. The case of the VR controller is different. Using the headset to establish the centre of the environment, the controller distance from this point is naturally limited by the length of the user's arms. This fact allowed the removal of the coded limiter but also added a new dilemma.

Different users will have different arm lengths, and with that, the maximum value they can achieve for the interactions will be different.

This made it clear that an exponential relation would be vital implementation on prototype 0.3 as a way to make different arm lengths redundant. Using an exponential relation between the head-to-hand distance and the movement of game objects allowed to, when reaching the maximum distance the user is physically capable of extending, limit the change rate making the different arm lengths negligible.

With prototype 0.2 it was understood that the user's field of view can be restrictive of what they are allowed to perceive. In this prototype, the global distance of the game objects to the user was kept the same as in prototype 0.1. When entering the VR environment it was hard to perceive objects. They would easily go out of the viewport, making it necessary for the user to move the head in a high range while doing small movements.

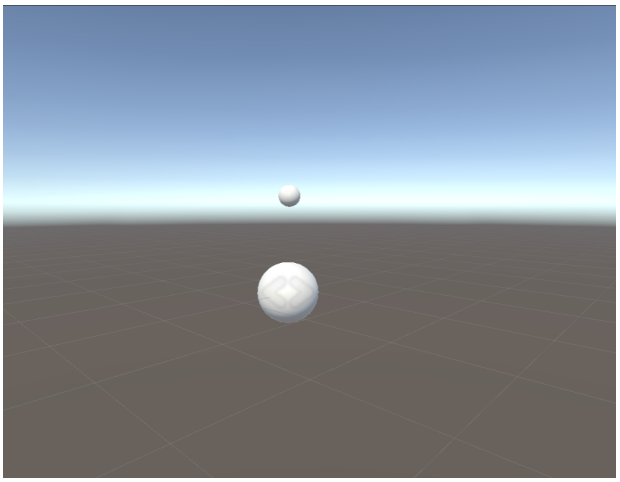

Figure 20 - Prototype 02 viewport

If, by default, this isn't a bad experience, allowing room to find movements where the head and body move with a high contrast, there should be also a way to allow users to fully make small movements, without being overwhelmed by the game object.

Answering to that, it was established that on prototype 0.3 more objects would be associated with the same interaction, varying in size, global distance and movement rate of change.

The next step in the prototype development was the implementation of the prototype 0.2 insights, activation of the interactions related to the second controller and introduction of the interactions using both controllers.

Prototype 0.3 was the first iteration where all the planned interactions were implemented. This prototype was actually planned to be the last phase of the Ideation phase but, after testing the prototype in-house, it was concluded that some adjustments were needed to reach a better and fuller experience.

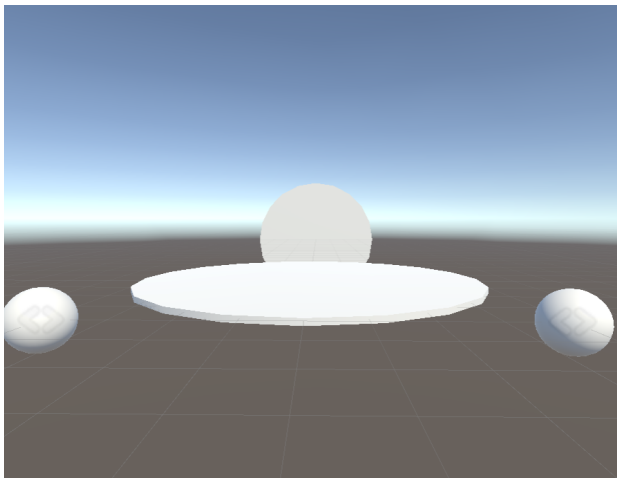

Figure 21 - Prototype 03 viewport

When interactions were implemented to each controller they were designed in a symmetrical and isolated fashion. This meant that for each controller there was a dedicated game object. The game object would incorporate all the interactions of their specific controller.

This dynamic led to two problems.

The first problem was the lack of connection between both hands. Being the interactions of the right hand isolated from the ones of the left hand, the user would experience a “virtual” separation of their arms. In the in-house testing users often forgot about interacting with one arm when their focus was on the other arm's game object.

The second problem was the constricted, or excess connection, users felt with game objects. With all controller interactions connected to the same object, they could not explore each unique interaction. The excess of connection made users feel overwhelmed like they were handcuffed to the game object, unable to disconnect from it.

To solve both problems a solution was proposed to be implemented on prototype 0.4. Instead of encompassing all single controller interactions to one game object, each game object includes interactions from both controllers. In the practical sense, one controller would control the orbital speed of object A while controlling the height of object B, and vice-versa.

Another problem found by in-house users was the lack of differentiation between game objects.

In prototype 0.3 all game objects were equal, the same size, same colours, to simplify iterations, but, with the in-house user's insights, the implementation of differentiated game objects appeared to be a necessity to allow them to keep track of what is happening in the VR environment.

These differentiated game objects were referred to in the interaction breadboard but were only planned to be added in the implementation phase. To understand if visually different game objects would help users to understand the behaviour of the environment better, this step was added to prototype 0.4.

The last step in the ideation phase was the implementation of all insights into prototype 0.4.

Prototype 0.4 included all the interactions and game objects of the proposed Virtual Reality Solution. Being an interaction prototype, as the previous iterations, it was developed using a greyboxing process, that is, using placeholders, so the prototype is playable, but to be afterwards replaced by 3d assets (Blevins, 2023).

For the first interaction group, a particle system was created. This particle system mimicked a smoke-like effect.

Figure 22 - Particle System 2d Texture

For the second interaction group, it was used three game-object groups. The first one was built using small spheres, with different height change rates, connected with the left controller.

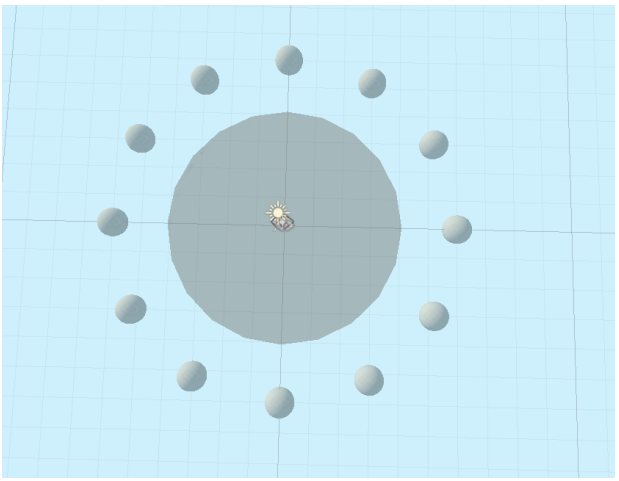

Figure 23 - Second Interaction Group, First Group

The second group was built with 8 equidistant spheres. These ones are larger than the ones from the first group. This group was connected by height, with the right controller, and by orbital speed, with the left controller.

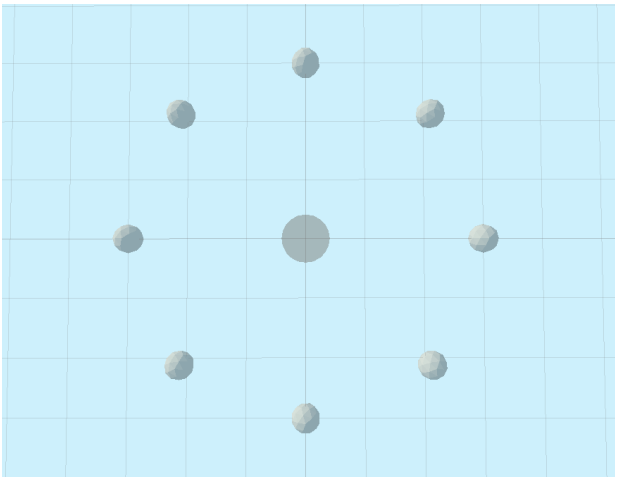

Figure 24 - Second Interaction Group, Second Group

The third and last group was built using only one game object. A sphere placed higher than the default viewport, that interacted, with orbital speed, with the right controller.

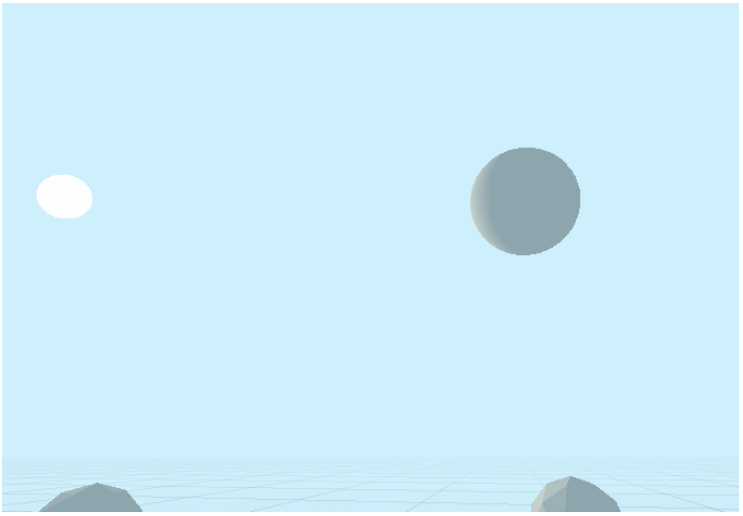

Figure 25 - Second Interaction Group, Third Group

For the last interaction group, it was used the same small spheres game object group.

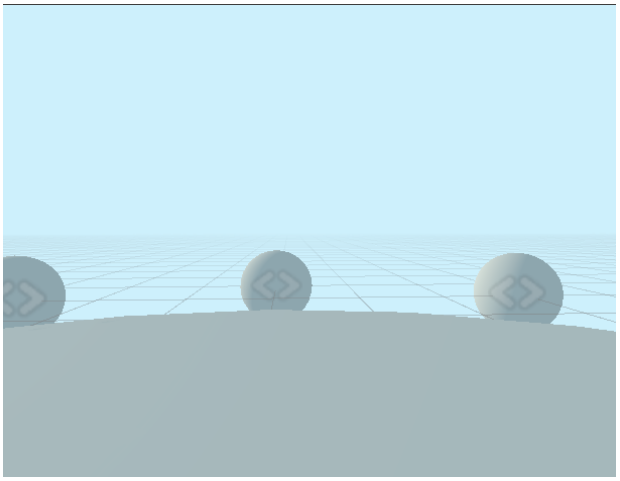

Figure 26 - Small Spheres on Prototype 0.4

With prototype 0.4 the ideation phase was closed and the prototype was ready for the implementation stage, where 3d assets implementation and visuals would be added and user testing would take place.

Implementation

The last step in the project development of the virtual reality solution is the implementation stage.

This stage was split into two crucial phases.

The first phase is the finalisation of the Minimum Viable Product. Using the greybox prototype developed in the Ideation stage, the look and feel of the solution will be defined, and interactions will be fine-tuned to go along with the established visuals.

The second phase is the user-test. In this phase, the MVP will be tested by users, with the goal of understanding the potential use of Virtual Reality in Dance Improvisation and Composition and finding the next steps of development of the VR solution proposed.

Being *Nabia* extremely visual and being the Minimum Viable Product in the proposed state only exploring visual perception, most of the user experience and inspiration will be dependent on visual elements.

For that reason, concepts such as colour, aesthetics and emotions were essential for the definition of the visual strategy.

Aesthetics and emotions are defined by Donald Norman as two of the three elements that are essential for a good and well-balanced user experience (Norman, 2004, pp. 8–10).

Aesthetics is an area of philosophical study closely related to Art. Centralized on the subjective experience of the observer, aesthetics is normally associated with the concept of beauty, imagination and perception (Walton, 2007).

Being defined as focused on subjective experience aesthetics differs between cultures, History, personal experiences and preferences. As Walton (2007) defends for what a culture comprehends as aesthetic can be completely understood as nonaesthetic to another and for that reason the study of aesthetics shouldn't focus on what is aesthetic, but how elements that are perceived as aesthetic influence behaviours and cultures.

> Aesthetics investigates the experiences and attitudes and activities of human beings and their cultural institutions, not just painted canvases, sounds emanating from sound-making devices, and inscriptions of words on the pages of books (p.54).

As such aesthetics research uses elements common in interaction and visual design such as colour, style and visual hierarchy to understand elements and how they alter behaviours.

Cognitive science and aesthetics research were understood as separate and non-influential areas of study. It was perceived function and beauty as two separate elements.

Masaaki Kurosu and Kaori Kashimura, in the early 90's claimed that aesthetics were part of what defined something more functional (Norman, 2004, pp. 17–20) .

This led to the understanding of how essential aesthetics are when developing user-friendly solutions. As Norman (2004) puts

> These and related finding suggest the role of aesthetics in product design: attractive things make people feel good, which in turn makes them think more creatively.

The choice of how elements appear in the proposed virtual reality solution environment is a great way to lead users into the specific state needed for Dance Composition and Improvisation.

In the Theoretical Framework section it was explored the role that Emotions have on IxD. Understanding that aesthetics, and visual decisions, can lead to certain Emotions steered this project into developing a visual moodboard, a guideline for asset development.

Before developing the moodboard the desired emotions to be visually explored needed to be defined.

Being the VR solution thought out as a composition and improvisational tool, visual elements should not limit the emotional spectrum to be explored by the user. At the same time, a simple greybox environment doesn't entail emotions, being almost lifeless and as such guiding users into and neutral and oblivious state.

All the visual elements in the environment should inspire users. Allow them to be creative and encourage them to explore all possible interactions while not guiding users to specific states thus limiting their exploration.

In modern and contemporary dance techniques nature have a prominent position as an inspiration for movement (Copeland, 2004, pp. 2–3).

Techniques such as the Release technique, Contact Improvisation and Flying Low explore nature as a inherent aspect of human reality, the laws of nature and nature's imagetic (Anderson, 2010, p. 16 & p.44).

At the same time, modern and contemporary choreographers also explore geometry, symmetry and assymetry as an element of inspiration and guidance for their movement (Copeland, 2004, pp. 84–85).

This geometrical approach to Dance composition originates from the detached feeling perfect geometrical elements have from real life. The lifeless aspect of geometry allows dancers to insert their own experience into choreographies, making the same choreographical element unique for each dancer (Diehl & Lampert, 2011, p. 215).

Both use of nature and geometric elements allows dancers to be inspired and at the same time personalize their dance experience.

Taking this into account, and with the desire to achieve a similar inspirational/Personalized state in the Virtual Reality solution as modern and contemporary dance, nature and geometrical elements were chosen as the guiding elements for the MVP Moodboard.

Looking into the game industry, because of the similarities with the VR development some examples of nature and geometry as balanced elements are found.

Figure 27 - No Man's Sky - Nature and Technology combined I

No Man's Sky is a PCVR-compatible space exploration and survival videogame. Based on Pop-Culture references such as *Dune*, *Elite* and *2001: A Space Odyssey* it explores a diverse set of space activities for players (Murray, 2015 && Stuart, 2016). In the game, players can engage in space battles, mine rare minerals, sell them in the in-game virtual trade system and explore and catalogue new planets and lifeforms, while experiencing the ongoing parallel story-telling.

No Man's Sky uses a procedural system to generate random star systems, planets and lifeforms allowing players to discover elements never seen before by other players.

The game universe bases itself in a dystopic universe, where most planets are in a similar life development state as Earth between the Paleozoic and Mesozoic Eras and at the same time, advanced civilizations, with space travel capabilities, live on space stations or small land outposts.

Because of this game visuals and game objects seek to cross the concept of untouched nature with extremely advanced and cryptic technology.

As such the visual concept for *No Man's Sky* follows a similar idea to the one proposed for the virtual reality solution.

Taking that into account some visual elements of *No Man's Sky* environment were chosen as an inspiration for the creation of 3D assets. In *No Man's Sky*, while nature follows a naturalistic colour approach with random object placement, technological elements tend to be extremely geometrical, with minimalistic and metallic colours, almost lifeless. The overall feel of the environment is also used as a reference point for *Nabia*.

Figure 28 - No Man's Sky - Nature and Technology combined II

Legend of Zelda: Breath of the Wild is a modern instalment of Nintendo's franchise, *Legend of Zelda*, developed for their console, Nintendo Switch (Nintendo, 2023).

Legend of Zelda takes place in a mythical universe, where untouched natural elements are placed alongside a medieval community with access to ancient advanced technology.

Figure 29 - Legend of Zelda: Breath of the Wild - Nature and Technology combined (Nintendo, 2023)

Players follow the story path of Link, the main character, who seeks to save the universe and Princess Zelda from evil forces (Nintendo, 2023).

Legend of Zelda was chosen to be part of the proposed VR solution moodboard for two reasons.

The first because, similar to *No Man's Sky*, it visually explores the intersection between nature and advanced technology, with minimalistic and geometric visual elements.

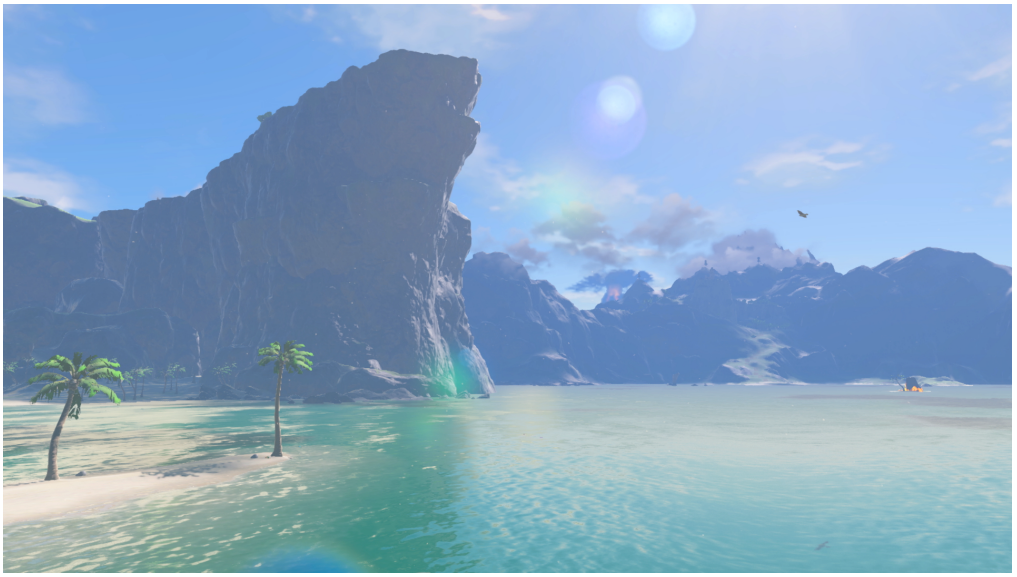

Figure 30 - Legend of Zelda: Breath of the Wild - Nature (Nintendo, 2023)

The second reason was because of the chosen platform for the game. Nintendo Switch being a handheld has limited processing resources. For that reason, visual elements were thought out and adapted for the platform limitations.

Being the VR solution also proposed to be implemented on Standalone VR, that is disconnected from the computer and only relying on the headset computing power, visual elements also need to follow a path where they don't surpass the headset's capabilities.

On *Legend of Zelda,* the strategy to allow the construction of compelling visual elements without surpassing Nintendo Switch's capabilities was as follows.

All 3D assets were built using a Low Polygon framework. That means that, when developing 3D assets, artists instead of seeking hyperrealism, which requires a high polygon count, went with a non-photorealistic (NPR) approach, using the minimum polygon count required to build the asset, without making it unrecognizable. "Non-photorealistic rendering is the means of generate imaging that does not aspire to realism." (Gooch & Gooch, 2001). This strategy gives 3d assets a visual keen to comic books and Cinema animations.

The overall environment used a shader that required less graphic processing capabilities.

Shaders in the context of 3D programs and video games are specialized programs or sets of instructions that dictate how light and materials interact, leading to the final visual representation of a 3D object or scene (Loviscach, 2004). These integral components play a pivotal role in determining various attributes, such as how surfaces reflect, refract, or emit light, which directly impacts the overall quality and realism of the rendered images and animations. By altering and manipulating parameters like colour, texture, transparency, and lighting, shaders empower developers to achieve an extensive array of visual effects and simulations.

In *Legend of Zelda: Breath of the Wild* it was used a minimalistic shader, that accentuates shades and glowing points in an intensive manner, giving the overall game visuals similarities with key Anime references such as *Howl's Moving Castle* and *My Neighbor Totoro*. These similarities allow the game to add into visuals an inspirational aspect, reinforcing the exploration aspect of Zelda's Universe.

This shader allowed the use of the hardware limitations as a way to accentuate the style and feel of the game.

Figure 31 - Legend of Zelda: Breath of the Wild - NPR Shader (Nintendo, 2023)

For the proposed Virtual Reality project a similar solution could enable a more concise and visually appealing environment without exceeding the *Quest 2* hardware.

Finally, Liminal, a VR solution already explored in the inspiration stage seeks to induce an inspirational environment for users. For that, they use elements such as water and simple shapes as objects that the user can interact with.

Figure 32 - Liminal - Use of water and simple shapes

The use of water to replace the ground gives the idea of infinity to the environment, creating a space that prompts the user to explore. Water movement, small and consistent waves, also give life to the Virtual Reality experience.

The use of simple geometric elements to interact with and the use of water to give life and inspiration to the proposed VR solution is in this way a viable approach.

Table 2 - Moodboard Analysis chart for selected software

Visual Characteristic	No Man's Sky	Legend of Zelda Breath of the Wild	Liminal
1. Based on	Based on Dune, Elite, and 2001: A Space Odyssey; blends pre-historic recreation with advanced technology	Based on a mythical universe blending nature with advanced technology	Natural elements, water, space, fauna interconnected with simple shapes
2. Platform Considerations	Compatible only for PCVR; Uses software optimization and hardware adaptability to overcome hardware limitations	Developed for Nintendo Switch with limited processing resources; adaptation to platform limitations	VR solution with inspirations for visuals; simple shapes and water usage
3. Polygon Optimization	Mid-polygon framework for realism and software optimization while maintaining a distinctive inspirational style	Utilizes hardware limitations to accentuate style; low-polygon approach for NPR visual style	Typical use of low polygon assets to keep software stable
4. Shader Usage	Realistic shader with day-night cycle for a realistic and immersive experience	Minimalistic shader emphasizing shades and glowing points for Anime-like visuals	Simple realistic shader for 3D software.
5. Inspirational Visuals	Based on Dune, Elite, and 2001: A Space Odyssey; seeks a cross between pre-historic recreation and advanced technology	Based on Anime references like Howl's Moving Castle and My Neighbor Totoro; reinforces exploration aspect	Natural elements, water, space, fauna interconnected with simple shapes
6. Hardware Limitations	Uses software optimization and hardware adaptability to overcome limitations; Compatible only for PCVR	Uses hardware limitations to accentuate style and optimize performance	N/A

With the moodboard defined the next step in the implementation phase is the development of 3D assets and visual elements.

To achieve a visually appealing MVP a Blender to Unity pipeline was created.

The main idea around the pipeline was an easy development and implementation of assets from Blender to Unity. Taking into account the time available to implement visual assets the pipeline needed to produce assets that were easy to be iterated and without complex dependencies.

For this reason, it was decided that textures and object materials would be implemented within Unity Engine, and from Blender it would only be developed the 3d Asset itself. In Blender, objects would have a temporary material that would mimic the intended material in Unity. This material would be previously developed in Unity using the greybox game objects.

To limit modifications preceding the implementation of objects on Unity, it was built in Blender a 1:1 scale of the simulated environment. In that way, visual elements could be tested without needing a full implementation on Unity.

When the desired visual hierarchy was achieved in Blender, the implementation on Unity would start, using the global position on Blender and replacing the greybox object while copying their material to the new 3d Assets.

In the implementation of visual elements on the Minimum Viable Product, some tweaks were made to the interactions.

For the particle system, in the first interaction group, the previous intention was the development of a smoke-like effect. This effect required a large amount of computing power. Not only that but the effect by itself didn't go according to the established moodboard. Smoke was too photorealistic, hard to see and looked out of place. For that reason, this system was replaced by an electric-like trail. This allowed the use of a vector file to produce the effect, instead of relying on a physics simulation thus reducing the computing power needed. This effect also produced light, instead of shadow as the smoke would produce, going in this way to the same visual direction intended with the moodboard.

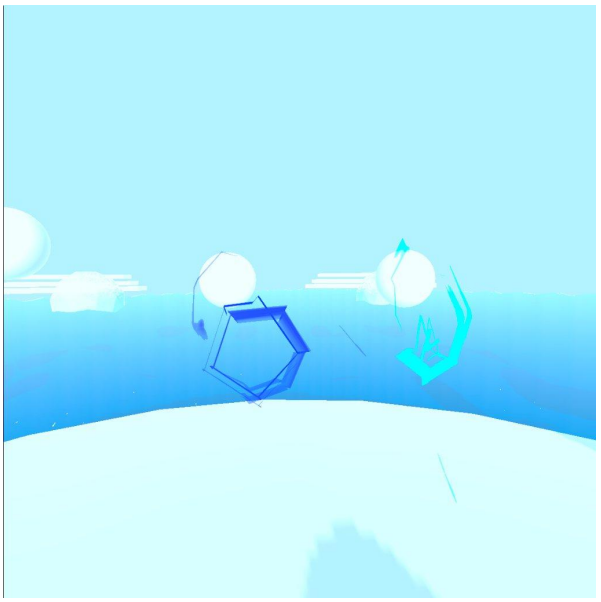

Figure 33 - MVP Particle System

While in the second group, no game objects were changed from the original proposition, a new group of game objects was added.

These new elements were first tested in the simulated environment. They were added in Blender to fill the empty space in the farther region of the viewport. This way user interactions could be related to farther objects allowing more creative space and potential movements.

These elements worked similarly to the small spheres, moving in relation to the height of a controller. They were controlled by the opposite controller that interacted with the small spheres.

Figure 34 - MV e Background

While all the small spheres changed their height at the same rate, the new element's rate of movement would be higher the farther away they were from the user.

This new group also moved orbitally, in opposition to the big spheres group and the floating object used in the prototype 0.4.

These objects needed to be different to the spheres to make their distance perceivable and the interaction more accessible. Instead of using spheres it was created an octagonal object group, built with stair-like objects.

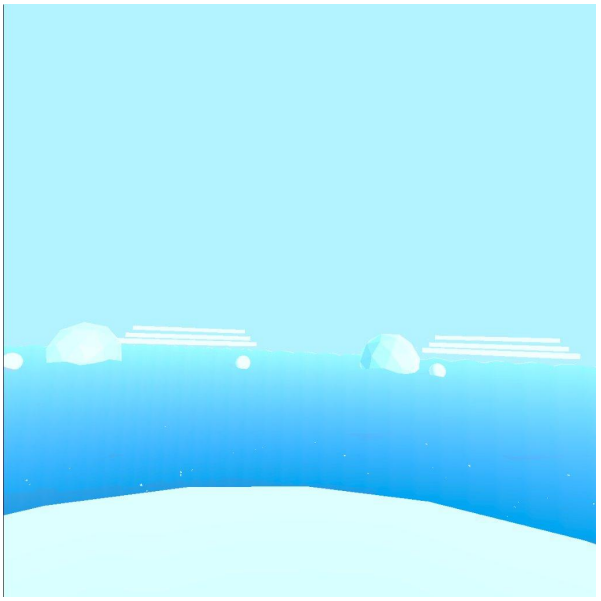

Figure 35 - MVP - New Gameobjects in the Background

The big sphere group gain a new interaction while losing the height interaction system.

To allow the exploration of micromovement the orbit interaction was changed. Objects would remain static while the controllers were in the neutral position, that is, hands near the hips. While the hands were near the hips game-objects would be rotating without changing their global position. This rotation would decelerate the closer the controllers were to the centre of the user's body. When the controllers went further from the hips threshold the orbit movement would start while the rotation movement would accelerate.

To make these interactions more obvious instead of using a fully cylindrical game object it was created on Blender a triangular sphere, that is a spherical object built using triangular faces.

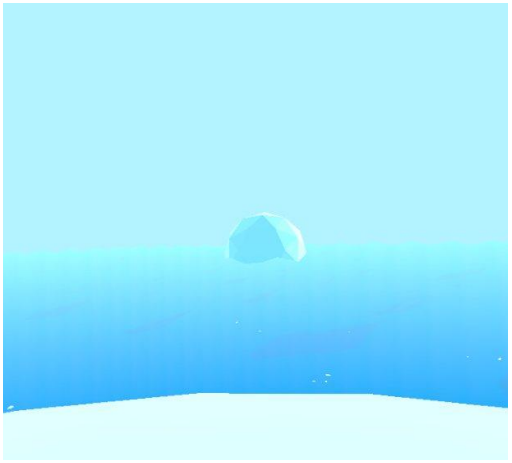

Figure 36 - MVP - Big Spheres with Triangular Faces

The floating object was kept the same, being built visually as a black hole, to separate itself from the rest of the objects.

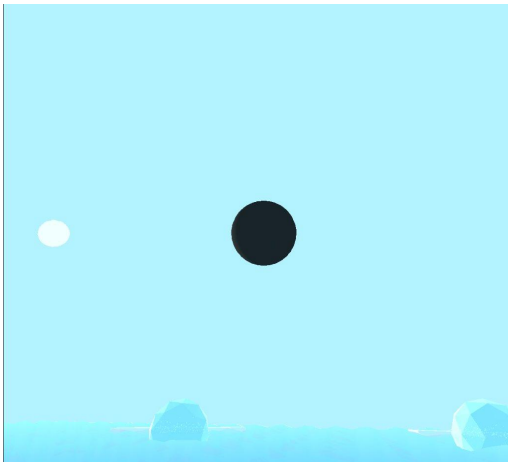

Figure 37 - MVP - Black Hole and Sun

Following the concepts found on the moodboard, the use of water as a way to entail infinity and the nonphotorealistic shader with clean and simple textures some elements were added to the MVP.

It was created an NPR sea, with permanent and calm waves. This ocean was placed in the neutral position of all game objects (except the floating black hole). Game objects didn't interact with the sea waves, but the ocean interacted with their colour. When the objects went below the sea level the submerged faces would become purplish. This way users could also interact with the sea without needing a physics simulation taking all hardware resources.

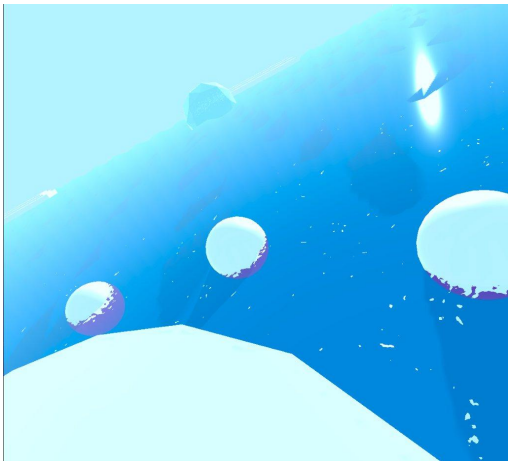

Figure 38 - MVP - NPR Sea

For the user, it was created a small platform above the sea level. This platform was used as a way to limit user movements to their safe area.

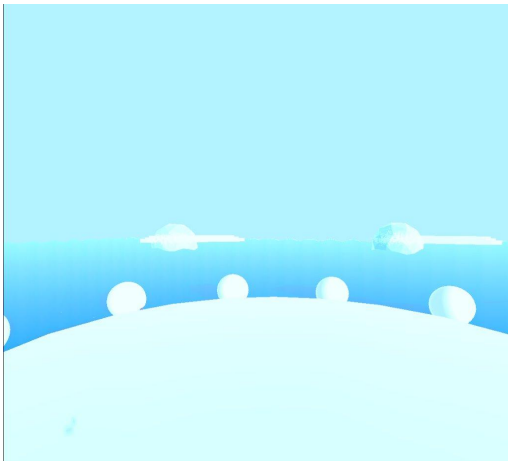

Figure 39 - MVP - User Platform and interactable elements

In all objects (except the floating black hole) was implemented a light grey, metallic texture.

Finally, inspired by the moodboard, this texture was chosen to entail an inspirational and almost ethereal energy to the environment, inviting exploration and movement. The black Hole used a black texture, with no reflection or refraction, to mimic the absence of light. This contrast between the black hole and the rest of the objects allowed space for exploration. This contrast was also enphasised by the presence of a static sun, occupying the same height, from the user's perspective.

With the visual implementation over, the next and final test for the Implementation Stage was the user-test.

The Minimum Viable Product was tested with four first-year students from the Higher School of Dance' Bachelor's Degree in Dance.

The User Test was composed of 3 practical tests, made in pairs and a questionnaire (User Test plan is presented in Appendix D). Due to the time needed for the practical tests two out of the four students responded to the questionnaire via a form, while the remaining answered the questionnaire in person.

The goals for the user-test were several.

First, the test was developed to understand the tool's potential for Dance Improvisation and Composition

Second, the test was intended to gather user insights, needs and pain points and understand how the virtual space inspired movement and allowed exploration.

Third, explore the hardware limitations, the use of the headset, the controllers, and possible known negative reactions to the Virtual Reality environment, like motion sickness and loss of awareness of the body placement in space, to find potential ways to circumvent the limitations

Lastly, the test was developed to understand the feasibility of interactions and build a general idea of the potential choreographic, exploratory or other uses for the Virtual Reality solution.

The first practical test, called *Environment Exploration*, sought the user's exploration of the Minimum Viable Product, without the knowledge of the specific interactions implemented. While exploring users explained what they were seeing and what they tought was the movement that made the objects change.

Three assumptions were made about this test.

Firstly it was expected that at first users would be overwhelmed by the amount of information to be seen in the environment.

Secondly, it was projected that users would explore interactions from the ones closer to them, the ones easier to perceive, to the ones farther away.

Lastly, it was also expected that users would at first move frenetically to see the environment reacting and during the exploration, they would become more precise with their movement.

When asked about the first impression of entering the virtual environment, all users referred to a sense of peace and balance, like they entered a completely different place. They felt immersed in the virtual world without feeling overwhelmed by the objects in it (interview transcripts are presented in Appendix E and quiz response in Appendix F).

Two of the users referred to the use of spheres, geometric objects, orbital movement and the sea as an inspiration for exploring movement in a calmer and circular manner.

During the exercise, three of the users explored the environment differently from expected.

One of the users started exploring from the objects farther away to the ones closer to her.

When asked about why she started exploring the farther objects she responded that for her she first explored interactions that had a bigger visual impact, and that moved more, and in the end, she focused on the interactions that were smaller and required less input from her. Curiously it was expected that the trails following the user's hands would be the first thing to be noticed, but in her case, she only became aware of them at the end of the first test.

Two other users focused first on the trails, as expected, but soon after shifted their focus to the farther away objects. When asked why, both gave a similar response from the previous user. They focused on the interactions that had a bigger visual impact.

The last user followed an analytical approach to the MVP, trying to understand each object and so exploring each object as assumed, this user was the only one that found the black hole also interacted with the movement.

When users were explaining what movement they thought was making an object react, most got it right almost instantly. Probably because the users were all dance students, when analysing each object they would try every instance of movement possible with precision instead of moving in a random way.

Without any external input users separated their body into three sections, left hand (left controller), right hand (right controller) and head (headset) and tested each movement with each section.

This strategy made it easier for users to understand how they could interact with the environment.

At the same time, all but one user was capable of understanding the interaction that used the distance between controllers. Being the only interaction that intentionally depended on both controllers, the strategy used by users didn't work as well.

Curiously two users found an unintended way of exploring interactions. The interactions that used the distance between the hand and the centre of the user utilized the headset as a way to pinpoint where the user centre was. With that users found out that they could fix their hand in space and move their head away from the controller to provoke a reaction in the environment.

The fact that users didn't feel overwhelmed with the environment while feeling immersed in it can be indicative that the amount of interactions implemented was well-balanced.

Also the ease in the way that users found how to interact with the environment can imply that the use of Laban Movement components established a common language between the virtual environment and dancers.

Lastly, the visual perception of the environment by the users, while achieving the purpose of inspiring exploration, also guided their actions into a circular and flow movement, mimicking the virtual sea. This tendency seen in the tests, and afterwards confirmed by users limited what users explored.

This highlights the paradoxical challenge in the visual and 3D asset development of this project. While the initial goal was to imbue the MVP with character for a more engaging and inspiring experience, this often clashed with the desired neutrality. When seeking user feedback, some suggested creating distinct environments that evoke various emotions while retaining the abstract visuals from the MVP.

Figure 40 - MVP User Test, first test - Tomás exploring VR world

The second test, called *Directed Focus*, intended the exploration of the interactions in a guided manner, beyond the functional exploration from the first test.

After the first test, all interactions were explained so every user knew everything they could do within the Virtual Reality environment.

The test consisted of verbally guiding the user into specific interactions so they could explore their movement

This second test used guidance as a way to familiarise users with the environment so they could safely test the limits to where their movement could go.

While a user was doing a guided exploration of the MVP, a second user would be taking the movement from the first as inspiration for their own.

With this system, the first user would be focused on the environment and at the same time communicate with movement their experience to the second user.

Because of hardware and time limitations, the environment recording wasn't implemented in the MVP. This test was also a way to test the potentiality of this feature, as a concept.

When asked about the movement limitations experienced by users, a common pain point was the hardware itself. The need to grab the controllers didn't allow the exploration of movement where the user's weight would be transferred to the upper body. The weight of the headset also limited their movement on the ground. This made all movement exploration dependent on verticality.

Figure 41 - MVP User Test, second test -Diana in VR and Tomás improvising using Diana's Movement

This limitation, as referred to before, was a known limitation of the solution. Being a Virtual Reality solution, and in the current state of the VR hardware, there's no easy way to circumvent this problem. When asked for solutions some users suggested the use of projectors in

place of the headset and the use of some kind of body tracking, replacing the controllers. While these suggestions could technically circumvent the movement limitation provoked by the hardware, in discussion with the users, it also had the potential to break some of the relevant features of the solution.

The use of a projected space, similar to a CAVE System, would allow more movement exploration but it would also reduce the user's immersion in the environment. Not only that but, with a projected system, the portability and flexibility of the solution would be fully lost. With the Meta Quest a user can use the solution in any dance studio instantly, but with a projected system users can only experience the environment in dedicated spaces.

On the other hand body tracking could be a functional solution. The Meta Quest have Hand-Tracking capabilities. This means that controllers could be removed from the experience totally. In the MVP this option wasn't explored because it would require more time in prototype development, which wasn't available.

Two users also referred to the desire to be able to interact with the VR environment with other body parts, like legs and torso.

Within the Meta Quest system, that wouldn't be possible. The headset doesn't have yet the capability to track other body parts by itself but there are some external solutions to circumvent this limitation.

One solution would be the use of an external camera, like the *Xbox Kinect system* (Ballester & Pheatt, 2013). This solution could achieve high-quality tracking but the experience would need more time to be set up, by the user.

Another solution would be the use of lightweight motion trackers like the *Sony Mocopy* (Sony, 2022). These motion trackers are composed of small trackers, each for a specific body part. Instead of relying on imaging to detect where the body is, this system uses gyroscopic data to compare each tracker's position to the rest of the group, in the 3d space.

These trackers are designed to be used while moving, being lightweight and slim devices.

With this technology incorporated into the VR solution, users would be able to explore a wider range of movement opportunities.

For this elegant solution, only one aspect appeared problematic. This technology is new, in the general consumer market. Because of that the resources for developing solutions with these

devices in mind are scarce. Not only that but these systems aren't widely available and most are too expensive, limiting the access to this VR Solution by users.

With time more access to these tracking devices is expected. When these devices become more easily accessible the idea of using them on the solution can be entertained.

At first, most users felt discomfort in exploring their movement. Being in a virtual environment, unable to see the external space and their body, movement exploration started slowly and conservatively. With time, and with the guiding assistance, users felt more comfortable and started exploring the possible movements.

> Senti a sensação de entrada numa nova realidade, num autêntico videojogo: como se de um personagem me tratasse, apesar de tomar as minhas decisões. Apesar deste último fator, levei a experiência como uma ausência de controlo do meu corpo, sendo este dominado pelo mundo virtual. (User quote from Appendix F)[8]

When asked how they felt their relationship was with the virtual space, there were some curious responses. One user said that even though she knew that the environment was always reacting to her movement she felt that sometimes the environment controlled her movement instead.

Another user said that they found himself in a reflexivity state. He said that at first, the movement was his, but the reaction from the environment would inspire him to do another movement. That movement would lead to a new reaction from the environment and that reaction would propel a new movement. This system developed into a truly dynamic duet where the user didn't find the separation between their movement intention and the movement reaction, turning himself into part of the virtual environment.

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[8] *English Translation using ChatGPT - I felt the sensation of entering a new reality, like being in a video game: as if I were a character, even though I made my own decisions. Despite this, I experienced a lack of control over my body, as it was dominated by the virtual world.*

> Por um lado, sentia que os objetos eram uma extensão do meu próprio movimento, ainda por cima, como nós não conseguíamos ver o movimento dos nossos próprios corpos, por causa dos óculos, era mesmo como se tivéssemos de fora de nós, de certa forma.
> Mas sim, por outro lado, o próprio movimento que nos... dos objetos à nossa volta também me dava inspirações. (User quote from Appendix E)[9]

The users also pointed out the potential to use the solution as a performative tool. When using the first user's movement as inspiration, the second user felt connected with the virtual environment, although they couldn't visualize it. Part of the reason for that, pointed out by a user, was the fact that they knew which interaction the user was exploring (because of the verbal guidance) and because they already knew how the environment behaved. When they saw the partner exploring, they were able to extrapolate how the environment was behaving.

This capability can be seen as a potential proof of concept, for the proposed recording feature. In the same way, users were able to extrapolate the environment behaviour from the partner's movement, there's the possibility, when exploring a recorded VR session, to envision the qualities of movement from the previous user.

The third test, named *Virtual Inspiration*, followed the same concept as the *Directed Focus* with only a difference, there wasn't any guidance, and the user was free to explore as they desired.

The results were similar to the ones from the previous test but more intense. With the power to react to the environment, they felt a deeper connection with the environment. Users reported that the immersion was profound. The movement exploration also gains new heights. Users were risking more, going out of their comfort zone.

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[9] *English Translation using ChatGPT - On one hand, I felt that the objects were an extension of my own movement, especially since we couldn't see the movement of our own bodies because of the glasses; it was as if we were outside of ourselves in a way.*

But yes, on the other hand, the movement of the objects around us also inspired me.

Figure 42 - MVP User Test, Third test - Tomás in VR and Diana improvising using Tomás' Movement

In the previous test, users maintained a similar rhythm throughout the test duration. In the *Virtual Inspiration* test users explored different rhythms and movement energies. They went from very precise to loose movement, from intense actions to relaxed ones.

When asked why this happened users responded that with the previous test, they started getting comfortable with the VR solution. When they started the third test they felt familiarised with the environment allowing them to truly explore. They said that this test was the point where they felt more free.

> Naturalmente senti-me bastante mais limitada, inicialmente por não ser uma zona confortável. Numa fase mais avançada sinto que os receios do espaço reduzido e de, com o uso dos óculos, mais reduzido mentalmente se tornava, não me terão permitido á exploração total possível e claro, o tempo delimitado para a atividade. (User quote from Appendix F)[10]

During the test a user suggested that in the next iterations, an in-game guiding system could be added, to simulate the experience of the second test, to allow users to get comfortable and familiarize themselves with the environment.

[10] *English Translation using ChatGPT - Naturally, I felt much more limited, initially because it wasn't a comfortable area. In a more advanced stage, I felt that the fear of the confined space and the mental limitations caused by wearing the glasses didn't allow me to fully explore. Additionally, the limited time for the activity also played a role.*

The idea of a tutorial stage in the virtual reality solution is a potential next step for the tool's development.

During and after the practical tests, user were asked what they expected to be the final version of *Nabia*.

A common answer was the creation of different environments, as referred to before.

Users proposed that the tool could have some environments already pre-made and, in addition, a way to add personalized environments by the user.

For users, this could widen the usage potential of the tool. Choreographers could develop their own environments for their work, teachers could create specific experiences to help and guide students in movement explorations, and dancers could create environments for their specific needs and moods.

This idea had a lot of potential and could be featured in two ways.

First, a simple upload system, where users would develop their environment and upload it to *Nabia*. This system is easily implemented, in a future state of the tool, but requires a deep knowledge of Unity development and 3d tools by the users. This requirement could be lessened with the creation of a Unity framework, with pre-made assets for users, but still needed knowledge of the development software.

A second solution would be the development of an in-game creation system, similar to what is found in games like *Garry's Mod* (Facepunch Studios, 2023) and *Boneworks*. This solution is complex and would require a great amount of time developing it, but, following IxD heuristics, could lead to a better and easier experience for the users. This second solution wouldn't be as customizable as the upload one, because users, to lessen the need for development skills, would still need to use pre-made interactions.

The implementation of both solutions would be ideal because it would give to the tool a wider possibility of personalization. Users who didn't want to create their environments could still use pre-made ones. Users that needed a personalized environment but didn't have the proper skills to work with the engine would still be able to build their environment in-game and users that required a fully personalized environment and had the know-how to do it, could upload their files.

To add to this proposal, if it was implemented an environment-sharing system users could share their own creations with others, similar to solutions like *Steam Workshop*.

Another proposal from the user was the implementation of audio interactions and day-night cycle, associated with a specific movement..

While performing the user test ambient music was used to get dancers more comfortable with the VR environment. Knowing that this music wasn't part of the MVP it was concluded that, because of the intrinsic relation between Dance and Music, adding music to the test could allow dancers to explore the solution without being completely out of their comfort zone. This strategy is commonly used in Dance improvisation jams (Pallant, 2006, p. 180).

When asked if users felt that their movements were actually connected with the music and not with the VR environment all responded negatively. They said that the music helped initially to get into the exploratory mood but didn't affect their exploration of the environment. Some even responded that they didn't remember listening to music in the last test.

Even though music didn't represent a major role in their experience they suggested that adding audio interactions could allow more exploration and immersion.

Lastly, users suggested some collaborative solutions. That is adding a way to have more than one person interacting in the same environment.

This is one of the proposed potential features to be added afterwards in *Nabia*.

Multiplayer capabilities would allow dancers to explore other dancer's movements in realtime, without needing to be in the same physical space. Exploration sessions and choreographical work could be done with people from all over the world, surpassing geographical limitations.

With the user-test ended, the implementation stage for the MVP was finished.

Final Comments

The main goal of this study was to create a Virtual Reality (VR) solution, *Nabia*, that merges interaction design and UX/UI concepts, allowing users to explore dance and movement through interaction. This entails developing a virtual environment where users can experience their movements and observe their impact within the simulated realm.

A key focus was seamlessly integrating dance movement into the VR setting, making movement the core mode of interaction. This required designing an interaction system that empowers users to manipulate the virtual environment with their movements, capturing the environment's responses.

Exploring VR's potential as a tool for movement exploration and choreography was also crucial. By combining the artistry of dance with VR's immersive capabilities, the aim was to offer users a fresh way to engage with movement and choreographic ideas.

Additionally, the study aimed to compare VR interface design and development with traditional interfaces. Through this analysis, we aimed to uncover similarities, differences, and the unique challenges and opportunities posed by VR technology.

An essential objective was assessing how dance movement can effectively interact within the VR environment. Through user feedback and testing, our aim was to evaluate the user-friendliness and experience of the VR solution, gauging its potential to inspire creative expression through movement.

Contributing to the comprehension of the convergence of virtual reality and dance was another goal. These evolving fields offer immense creative and technological possibilities. By venturing into this unexplored territory, the study aimed to offer insights that could steer the future evolution of VR applications and dance practices.

Lastly, the study aimed to chart future research directions in the VR and dance realm. By highlighting pathways for refinement, expansion, and practical use, the goal was to kindle further innovation within this captivating interdisciplinary domain.

Our MVP development project has shown the strong connection between Interaction Design and Game Design within the VR domain.

It's clear that established design principles such as IDEO's human-centred approach, MDA framework and UX Heuristics are not only applicable but essential in crafting effective VR solutions.

In the Game industry there's a growing focus on user experience and interaction design, primarily because of the fierce market competition, making the user experience a focal point to differentiate the product in the market (Ng & Khong, 2014). In the same way, by the similarities in development, Virtual Reality can gain from this user-centered approach. The development of the proposed VR solution, using IxD as a driving force for the development process showed that design principles enhance VR user experiences, ensuring immersion and usability.

Focusing only on the technical aspects of development on Virtual Reality can't achieve positive solutions for the user but by merging Interaction Design and Game Design in VR and leveraging IDEO's methodology, Game Design and UX Heuristics, we allow innovative VR solutions with profound applications in communication, education and entertainment.

By achieving these goals, the research aimed to bridge the gap between virtual reality technology and dance, ushering in innovative forms of artistic expression, interaction, and exploration.

With the Minimum Viable Product design process closed some conclusions can be made, using the insights gathered in all the design stages.

The proposition of using Virtual Reality as a platform for movement exploration and composition presented itself as a potential solution. With the development of the Minimum Viable Product, it was possible to understand the relationship between the virtual environment and dancers and future solutions for this Virtual Reality tool.

Looking into the Movement Workshop and the MVP User-Test is possible to accept that VR, as other technological means already used in Dance, could be a driving factor that would lead to new solutions, movements and ideas in this Artform.

The use of VR showed as a way to filter out the direct imagetic of movement, allowing dancers to access movement intentions.

As a choreographic tool, the Virtual Reality solution showed the potential to become a new framework for Dance Composition.

The insights from users lead to the establishment of possible pathways for the solution developed.

The possibility of sharing environment recordings and the creation of new VR environments could lead the way to the democratization of Dance. Allowing Dancers and

Non-Dancers to explore the intentionality and movement of other Dancers and Choreographers without looking into physical and geographical limitations.

From the technological standpoint, the proposed tool and the results have shown the potential of VR solutions beyond the conventional development pathway of Virtual Reality

As referred to in the Theoretical Framework VR is dominated by the gaming industry, being this industry the leading establisher of design processes and frameworks for Virtual Reality.

Even though other uses for VR were also referred to, Health, Medicine and Productivity, the development of this solution, for Dance, proves the potential of VR to be used in other areas.

Following the results of this project it is possible to iterate the next steps for the development of the Virtual Reality solution.

The insights gained from the User-Tests provide valuable guidance for defining the VR solution's future development.

Firstly, the user feedback suggests the potential for diversifying the virtual environments. This could offer choreographers, teachers, and dancers a dynamic range of options tailored to their specific needs. With the implementation of an upload system and the development of an in-game creation system, *Nabia* could really become a dynamic tool instead of a static virtual reality experience.

Moreover, incorporating audio interactions presents a promising avenue for deeper immersion. While music did not significantly affect users' exploratory experiences, the idea of introducing audio interactions garnered interest. This feature could infuse the VR environment with more sensory dimensions, potentially stimulating further exploration and creative expression.

The concept of enabling collaboration within the virtual space holds great promise. Introducing multiplayer capabilities could revolutionize the way dancers interact across geographical boundaries. Real-time interaction between users, irrespective of their physical locations, could spark collaborative movement exploration and choreographic work on a global scale.

With the proven interactions from the MVP and the user insights, it can be seen as an argument for the shift in perspective of the tools development. Until now the goal was exploring movement as a means of interaction in a Virtual Reality environment. The potential shown by the interaction between users and the tool not only proved the feasibility of movement as a means of interaction but also presented an opportunity to develop a platform-like solution.

With this the question changed from if the movement can be used for interaction to how can users establish their own interactions and share with others, allowing the creation of a movement creation and exploration community.

Before starting the next phase of *Nabia*, the limitations presented in user testing need to be addressed. The use of alternative solutions for body tracking needs to be taken into account.

Although adding elements such as body trackers can complexify the tool, if the tool is thought out to be able to work with and without these elements, the bridge between full body immersion and the hardware can be tackled by the user with more flexibility.

Finally, with the conclusion of this project, it is believed that the continuous exploration of VR/AR solutions with diverse areas of interest is a stepping stone to the future. Developing tools in VR/AR can break geographical and local limitations, and, with the democratization of VR hardware, be a solution for sharing knowledge and experiences.

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Appendices

Appendix A - Movement Workshop Plan and Script

UX Goals:

- Understand User needs, wants and pain points
- formulate ideas, and segment the project user
- Understand feasibility of certain interactions

Process Goals:

- Test *Space Interaction* hypothesis with direct movement and projected movement.
- Test *Time Interaction* Hypothesis with movement from someone else.
- Understand choreographic potential with movement exploration

Keep in Mind:

- Movement with the quest is limited.
- Music can exist as an addon, just for inspiration and familiarization with the VR environment.
- Motion Sickness is a problem and the Headset getting hot can be uncomfortable
- The headset is Heavy
- The battery drains rapidly, it will need the power bank

Tests (All with Open Brush):

- Moving and Drawing in the 3D Space: User moves and draws in the 3D space, movement directly associated with hands position.
- Projected movement into Environment: *B* User uses *A* user registered movements, projected into the environment, as an inspiration mechanism.
- Dancer Sees, Dancer Mirror: *A* User uses the headset to see the environment and moves as it pleases. *B* User Mirrors the Movement with the Controllers.
- Dancer Sees, Dancer Move: *A* User uses the headset to see the environment. *B* User Moves as it pleases registering the movement with the controllers. *A* User uses *B* user movement as an inspiration point for exploration.

Workshop details:

- only 2 participants per test
- Can use a chair if it feels motion sickness
- Needs a studio

Workshop Structure:

Introduction:

- Present the project
- Present the workshop and goals
- Get to know the users (Who are they, Dance Background, Contact with VR)
- Hazards and things to keep in mind

Movement Workshop:

- Introduce Open Brush and explore for 2 minutes
- Moving and Drawing in the 3D Space
- Projected Movement in the Environment
- Dancer Sees, Dancer Mirror
- Dancer Sees, Dancer Move

Main Questions:

- How does it feel to depend on buttons to register movement? What would you change?
- Did you feel Claustrophobic in any part of the workshop? why?
- What were the strategies you used to get inspiration from the environment?
- Did you feel your movement was limited (more than with the things to keep in mind)? How? Why? What would you change?
- How was the experience of seeing your movement translated into lines following your hands? and when the movement was translated far away?
- How was the experience of using the static result of movement as an inspiration for exploration? and how was the experience when the movement was time-bounded?
- Did you prefer to see all movement in the space being added or would you enjoy it more if it faded away? why?

Wrap-Up:

- What are your expectations for this project?
- If I could give you a final version of the project where would you use the VR solution?
- Thank you note.

Appendix B - Movement Workshop in-house notes

March 23rd, 2023 - Movement Workshop with Catarina (João for the third time didn't attend, can't find anyone to replace him)

Note before starting: Test will be adapted to be done by Catarina and I. I will have action in the exercises that need two people, but my feedback will not be registered.

Notes:

- Catarina felt that she "rapidamente desconectei a minha mente das limitações do meu corpo" (eng translation - rapidly disconnected my mind from the limits of my body), she explained saying that normally when she does exploratory work she needs time to lose the shyness and enable herself to really go beyond her confort zone. She claimed that in VR, because of the immersion she immediately entered in that state.
- Catarina felt in the beginning difficulty connecting her movement to the vr environment of OpenBrush, but that difficulty dissolved the more she spent time in the VR environment.
- About the first question Catarina answered saying that she could choose when she wanted to register movement, but the fact that the movement didn't dissipate was overwhelming.
- Catarina said that she thinks that it would be possible to create a choreographic pipeline using the lines. Creating lines in the environment and allowing a second person exploring it would serve as a way to communicate artistic intention.
- The space was a dark void, allowing Catarina to forget about physical limitations, like gravity, but the headset and controllers constrain her from exploring more. The weight of the headset and the presence of the controllers didn't allow her to explore more. "Eu queria explorar mais, explorar o chão, saltos, mas o peso dos oculos e os comandos nas mãos limitavam-me não só fisicamente, como tinha o medo inerente de partir os aparelhos" (Eng translation - I wanted to explore more, explore the floor, jumps, but the weight of the headset and controllers in the hands limited me not only in the physical way but also because I was afraid of breaking the hardware.)
- Catarina also felt that this limitations could also be enhancers for other movement. "Por outro lado os limites forçaram-me a procurar novas soluções para o movimento,

permitindo-me explorar mais, acho que se queremos explorar o mundo virtual devemos explorar as limitações do mesmo" (eng translation - In other hand, the limits imposed by the hardware forced me to find new solutions for movement, allowing me to explore more. I believe that if we want to explore the virtual world we should also explore the limitations of it).

- Catarina referred that the fact that in OpenBrush the hand has the sole mean of interaction in the environment lead her to base all her movement on the hands.
- About the second question Catarina didn't feel motion sickness or any sign of claustrophobia, and said that the fact that the environment extended to the infinite allowed her to go beyond her confort zone.
- Catarina said that some times lines in the VR environment were her starting point for movement, but other times the creation of them lead her to move.
- When asked about strategies used for exploration Catarina referred the use of different body parts, use of lines in the environment was trajectories, and associating lines characteristics to parts of the body.
- Catarina described the feeling of seeing her movement projected in the environment (dancer sees, dancer mirrors) almost out-of-body, cryptic, but allowed her to explore beyond her confort zone. "Era uma sensação estranha, quase fora do corpo, ao inicio assustador, mas quando me habituei senti vontade de explorar como o espaço reagia, levando-me a ir para lá do meu movimento comum" (Eng Translation - It was a strange sensation, almost out of body, initially frightening, but when I got used to it, I felt a desire to explore how space reacted, leading me to go beyond my usual movement.)
- About the forth exercise Catarina felt "como um fantoche" (like a puppet) but she felt she had the choice of which line to follow and when. The fact that the lines were dynamic, in her perspective, allowed a deeper connection with my movement.
- Catarina felt that overall the experience led her to explore, but in the end, the accumulation of lines in the environment became unbearable and she would get lost. She suggested to have this lines in the proposed solution but that would dissipate afterwards. She believed that the exercises were a good fit for exploration and dance composition.

Catarina's suggestions for the proposed solution:

- The environment can't be fully blank. It needs something to entice movement. Visual inspiration.
- Recording the sessions in vr would allow others to explore the dynamics from the first user.
- Thinking of the VR solution was a way not only to inspire choreography but to be part of the resulting choreographical work.

Appendix C - Movement Workshop ESD notes

ver as linhas deu power ao movimento

July 5th, 2023 - Movement Workshop at ESD with Diogo and Deolinda

Note before starting: this notes were taken while the movement workshop was undergo. The responses to the questionnaire will be taken afterwards and recorded. The recorded responses also included answers for the User Test Questionnaire

Notes:

- Diogo was the first exploring the vr environment. He felt comfortable in the environment immediately and said that seeing the lines coming from his hands gave him more power to the movement. He felt the desire to create lines and explore their position in space.
- Deolinda felt comfortable in the vr environment but had a slower start than Diogo. She said she felt weird not being able to see her body.
- Both users showcased and referred a tendency for rotative movement , saying that this tendency was because the movement in OpenBrush was fully based on the hand movement.
- Diogo had difficulties with the headset. When he started doing more complex and faster movement the headset would move making the image blurry.
- Deolinda felt, one on side free to move in the environment, feeling able to explore beyond her movement, but at the same time the headset weight and the controllers didn't allow her to move to the floor. She said that this limitations made her explore beyond the hardware limitations being a motive to find new movement.
- Neither of the users felt motion sickness and both refered that the infinite space invited them to explore.
- Deolinda, in the third exercise said that, in the end, she wasn't able to keep her attention in the lines because it was too many on the environment. She suggested to have a way to dissipate them after a while.
- Both users said that they felt a connection when doing the third and forth exercise. They suggested the use of the software for choreographical purposes.

Appendix D - User Test Plan and Script

UX Goals:

- Understand User needs, wants and pain points
- formulate ideas, and segment the project user
- Understand feasibility of certain interactions

Process Goals:

- Test Movement Exploration with VR environment.
- Understand how the space inspires the movement.
- Understand choreographic potential with movement exploration.

Keep in Mind:

- Movement with the quest is limited.
- Music can exist as an addon, just for inspiration and familiarization with the VR environment.
- Motion Sickness is a problem and the Headset getting hot can be uncomfortable
- The headset is Heavy
- The battery drains rapidly, it will need the power bank

Tests:

- Environment Exploration: User will explore the environment freely (With calm music) while saying what they think the interaction is. (It will not be corrected) Second user will do the same directly after with the info from the first user. Afterwards interactions can be explained if needed.
- Directed Focus: User A directs User B into specific outputs from the VR environment. They change and Repeat.
- Virtual Inspiration: Um explora freely enquanto o segundo utiliza o movimento como elemento de inspiração. (Can't Record Yet)

Workshop details:

- only 2 participants per test
- If motion sickness appears stop
- Needs a studio

User Test Structure:

Introduction:

- Present the Prototype and goals
- Hazards and things to keep in mind

Movement Workshop:

- Environment Exploration
- Directed Focus
- Virtual Inspiration

Main Questions:

- What did you feel looking into the environment? How did it inspire you?
- Explain the connection you feel with the environment. Did you focus in any particular interaction? why?
- How free did you feel? Could you explore all the movement you wanted? Did you feel the need to be always connected with the environment? Why? Why not?
- How was the experience of seeing your movement translated into virtual objects? Did the objects give you inspiration (free session and guided)?
- The movement wasn't time bounded, how did it feel compared with the workshop?

Wrap-Up:

- Would you change or add features? What? Why?
- Thank you note.

Appendix E - User Test Transcript, first group

Notes: For lack of available time with the users the following interview was about the movement Workshop and User Test, at the same time. Users answered about both experiences. Interview was done by Catarina while I was conducting the user test with the second group.

00:00:02:19 - 00:00:17:19

Catarina

O que é que sentiram ao olhar para o ambiente? O que é que vos inspirou? Assim, muito breves.

00:00:17:21 - 00:00:20:08

Diogo

Mas relativamente à última parte?

00:00:20:10 - 00:00:25:03

Catarina

Sim, sim. Ao último ambiente.

00:00:25:05 - 00:02:20:24

Diogo

Agora ainda estou um bocado confuso. Para já, o ambiente do mar, à nossa volta, e o facto de as esferas, as esferas e pronto aquelas escadas, aqueles retângulos também se moverem em círculos, aquilo que me vinha à cabeça eram movimentos mais ondulantes. Pronto, cíclicos. Faz sentido.

A imagem que me surgiu foi mesmo a de uma galáxia. Tentar transpor uma galáxia para o corpo. O movimento. Daquilo que eu vi, não da forma como estava a manipular as figuras.

Só daquilo que eu vi era isso o que eu sentia, era isso que eu sentia, porque era um movimento circular em que todas essas figuras tinham diferentes velocidades, tinham sempre uma trajetória circular, tirando as esferas que se aproximavam e afastavam, que subiam e desciam.

00:02:21:01 - 00:03:16:18

Deolinda

E eu achei que foi um ambiente assim interessante, bem escolhido, porque tínhamos por onde explorar, podíamos aproximar e afastar as esferas. E também tínhamos aquele buraco negro que não estava nada à espera que é mais em cima, a nossa visão é mais... Estamos a ver as coisas mais aqui no meio, e depois podemos olhar também mais para cima... Também gostei das linhas que tínhamos nas nossas mãos. Nem tinha focado nisso, mas foi a primeira coisa que nós exploramos. Achei mesmo interessante, voltamos ao primeiro exercício das linhas.

Também, enquanto estava a fazer o exercício, estava a tentar encontrar bons movimentos para que o meu colega pudesse ter um bom conteúdo para imitar, para se inspirar e criar o seu próprio movimento.

00:03:16:20 - 00:03:49:24

Catarina

E que conexão é que sentiram com o ambiente, se tiveram alguma interação particular e se acharam alguma coisa, um ponto focal? Já tinhas falado que sentiste com o buraco. Sentiste mais alguma conexão com alguma das características? Qual é que seria o maior foco?

00:03:50:01 - 00:03:58:16

Diogo

Eu acho que era mesmo o controlo sobre a paisagem, era mesmo o controlo sobre a paisagem.

00:04:05:17 - 00:04:12:20

Catarina

Sentiram-se livres para explorar todos os movimentos que criavam? Capazes de criar?

00:04:12:22 - 00:04:45:16

Deolinda

Sim, é diferente ter que dançar com os óculos porque não consigo ver o meu corpo. Dificulta o meu awareness, é difícil ter consciência do meu espaço, porque o espaço que eu estou a ver não é o espaço onde eu estou inserida, não é o meu espaço físico. Mas sempre que podia explorar, mesmo tendo o limite, tentei sempre não passar dele e sim senti liberdade.

00:04:45:18 - 00:05:28:09

Diogo

O que eu senti foi que sim, havia ali liberdade, mas pronto, isto foi mais daquilo que eu senti, não o que... Eu podia me mover, mas podia ter-me movido mais. Mas com aquilo tudo à minha volta, eu senti-me mais, tipo uma torre, e depois é como se saísse alguma coisa de mim.

00:05:28:11 - 00:05:41:02

Catarina

Sentiram sempre necessidade de estar conectados ao ambiente ou podiam estar fora da conexão que tinham com os elementos no ambiente?

00:05:41:04 - 00:06:06:22

Deolinda

E eu tentei sempre respeitar as premissas que me foram dadas, tentar explorá-las e tentar seguir o seu movimento. Havia partes que eu desconectava um bocado, para explorar mais o espaço que tinha à minha volta, mas sempre senti uma conexão com o espaço virtual.

00:06:06:24 - 00:06:21:05

Diogo

Sim, eu também, especialmente neste último eu automaticamente estava conectado com o espaço, nem sequer era posto em causa afastar-me daquela realidade.

00:06:30:17 - 00:07:04:06

Catarina

Como é que sentiram ao verem que o vosso movimento era traduzido para outros movimentos nas figuras e se isso nos deu inspiração? Se os objetos, se a resposta que vos era dada pelos objetos vos dava inspiração para continuar? Através de uma sessão guiada, como fizemos mais ou menos aqui, ou completamente livre, simplesmente explorarem.

00:07:04:08 - 00:07:07:10

Deolinda

É sobre o primeiro exercício com as linhas...

00:07:07:12 - 00:07:16:08

Catarina

Com este agora, o último, sim.

00:07:16:10 - 00:07:25:09

Diogo

Podes só repetir a pergunta outra vez, por favor?

00:07:25:11 - 00:07:43:05

Catarina

Eu vou tentar fazer mais curta. Para ser mais fácil. Se o movimento que os objetos... houve movimento que vocês faziam que tinham um reflexo nos objetos. Se o movimento que os objetos refletiam dava retorno de volta, dava inspiração para continuar?

00:07:43:07 - 00:08:18:07

Diogo

Sim, sim, é mesmo isso. Por um lado, sentia que os objetos eram uma extensão do meu próprio movimento, ainda por cima, como nós não conseguíamos ver o movimento dos nossos próprios corpos, por causa dos óculos, era mesmo como se tivéssemos de fora de nós, de certa forma.

Mas sim, por outro lado, o próprio movimento que nos... dos objetos à nossa volta também me dava inspirações.

00:08:18:09 - 00:08:41:20

Deolinda

Eu senti que inspiravam mais o movimento quando eu estava com as linhas, porque era eu que as controlava no ambiente e senti mais isso com as linhas outra vez, que tinha no comando, e talvez com o mar. Quando eu podia subir e descer as esferas e elas iam para o mar, inspirou-me mais.

00:08:41:22 - 00:09:12:16

Catarina

E em relação com este ambiente, ultimamente ambiente que tiveram e as linhas? O que sentiram em termos de exploração temporal? Em termos de... O workshop foi um caminho mais curtinho. Foi para a troca e para troca. O segundo já foi só um bocadinho mais extenso. O que é que sentiram?

00:09:12:18 - 00:09:30:07

Deolinda

Eu acho que tivemos tempo para explorar o conteúdo desta experiência. Gostava de ter tido mais tempo, claro, mas mesmo assim conseguimos perceber o conteúdo.

00:09:30:09 - 00:09:46:15

Diogo

Assim. E sinto o mesmo, especialmente na segunda parte, deu mesmo vontade de explorar mais, ficar mais tempo a explorar. Foi isso o que eu senti.

00:09:49:02 - 00:09:56:14

Catarina

Tem alguma coisa que gostassem, se tivessem a oportunidade de adicionar alguma coisa e retirar alguma coisa, o que é que seria?

00:09:56:16 - 00:10:06:20

Deolinda

Se calhar se desse mesmo para pegar na esfera, não sei. Acho que seria interessante. Poder controlá-la.

00:10:06:22 - 00:10:18:10

Catarina

Como fazes com as linhas?

00:10:18:10 - 00:10:18:12

Deolinda

Sim.

00:10:18:12 - 00:10:47:10

Diogo

Não sei. Agora surgiu-me uma ideia, de algum movimento específico, como aquilo se passa durante o dia haver essa transição de dia para noite? Esses ciclos provocados por um movimento específico. Não sei, surgiu-me essa ideia. Mas sim, acho que não acrescentava assim muito mais.

00:10:47:12 - 00:10:55:13

Catarina

E tudo, obrigada. Foi muito bom o feedback. Acho que é importante e espero que tenham gostado.

Interview transcript translated using ChatGPT

00:00:02:19 - 00:00:17:19

Catarina

What did you feel when looking at the environment? What inspired you? Very briefly.

00:00:17:21 - 00:00:20:08

Diogo

But regarding the last part?

00:00:20:10 - 00:00:25:03

Catarina

Yes, yes. The last environment.

00:00:25:05 - 00:02:20:24

Diogo

I'm still a bit confused now. First, the sea environment around us, and the fact that the spheres, the spheres, and those stairs, those rectangles, were moving in circles, what came to my mind were more undulating movements. Well, cyclical. Does it make sense?

The image that came to me was that of a galaxy. Trying to transpose a galaxy onto the body. The movement. From what I saw, not the way I was manipulating the figures.

Only from what I saw, that's what I felt, because it was a circular movement in which all these figures had different speeds, always had a circular trajectory, except for the spheres that approached and moved away, going up and down.

00:02:21:01 - 00:03:16:18

Deolinda

And I found it to be such an interesting environment, well chosen because we had room to explore, we could approach and move away from the spheres. And we also had that black hole that I wasn't expecting, which is higher up, our view is more... We see things more in the middle here, and then we can also look higher... I also liked the lines we had in our hands. I hadn't even focused on that, but it was the first thing we explored. I really found it interesting; we went back to the first exercise with the lines.

Also, while doing the exercise, I was trying to find good movements so that my colleague could have good content to imitate, to be inspired by and create their own movement.

00:03:16:20 - 00:03:49:24

Catarina

And what connection did you feel with the environment, if you had any particular interaction and if you found something, a focal point? You already mentioned that you felt it with the black hole. Did you feel any other connection with any of the features? What would be the primary focus?

00:03:50:01 - 00:03:58:16

Diogo

I think it was really about control over the landscape, it was really about control over the landscape.

00:04:05:17 - 00:04:12:20

Catarina

Did you feel free to explore all the movements you created? Capable of creating?

00:04:12:22 - 00:04:45:16

Deolinda

Yes, it's different to have to dance with the glasses because I can't see my body. It hampers my awareness; it's difficult to have a sense of my space because the space I see is not the space I'm in, not my physical space. But whenever I could explore, even with the limit, I always tried not to exceed it, and yes, I felt freedom.

00:04:45:18 - 00:05:28:09

Diogo

What I felt was that, yes, there was freedom there, but well, this was more about what I felt, not what... I could move, but I could have moved more. But with everything around me, I felt more like a tower, and then it's as if something came out of me.

00:05:28:11 - 00:05:41:02

Catarina

Did you always feel the need to be connected to the environment, or could you be disconnected from the connection you had with the elements in the environment?

00:05:41:04 - 00:06:06:22

Deolinda

And I always tried to respect the premises that were given to me, tried to explore them and tried to follow their movement. There were times when I disconnected a bit to explore more of the space around me, but I always felt a connection with the virtual space.

00:06:06:24 - 00:06:21:05

Diogo

Yes, me too, especially in this last one, I was automatically connected to the space, it wasn't even a question of moving away from that reality.

00:06:30:17 - 00:07:04:06

Catarina

How did you feel when you saw that your movement was translated into other movements in the figures, and if that gave you inspiration? If the objects, if the response given to you by the objects, inspired you to continue? Through a guided session, like we did here more or less, or completely free, just exploring.

00:07:04:08 - 00:07:07:10

Deolinda

It's about the first exercise with the lines...

00:07:07:12 - 00:07:16:08

Catarina

With this one now, the last one, yes.

00:07:16:10 - 00:07:25:09

Diogo

Could you please repeat the question?

00:07:25:11 - 00:07:43:05

Catarina

I'll try to make it shorter. To make it easier. If the movement that the objects... there was movement that you were making that had a reflection on the objects. Did the movement that the objects reflected back inspire you to continue?

00:07:43:07 - 00:08:18:07

Diogo

Yes, yes, that's exactly it. On one hand, I felt that the objects were an extension of my own movement, especially since we couldn't see the movement of our own bodies because of the glasses; it was as if we were outside of ourselves in a way.

But yes, on the other hand, the movement of the objects around us also inspired me.

00:08:18:09 - 00:08:41:20

Deolinda

I felt that they inspired more movement when I was with the lines because I was the one controlling them in the environment, and I felt that more with the lines again, that I was in control, and perhaps with the sea. When I could move the spheres up and down, and they went into the sea, it inspired me more.

00:08:41:22 - 00:09:12:16

Catarina

Regarding this environment and the last environment you had, and the lines, what did you feel in terms of temporal exploration? In terms of... The workshop was a shorter path. It was for the exchange and back. The second one was a bit longer. What did you feel?

00:09:12:18 - 00:09:30:07

Deolinda

I think we had time to explore the content of this experience. I would have liked more time, of course, but even so, we managed to grasp the content.

00:09:30:09 - 00:09:46:15

Diogo

Yes, that's it. I feel the same, especially in the second part; it really made me want to explore more, to spend more time exploring. That's what I felt.

00:09:49:02 - 00:09:56:14

Catarina

Is there anything you would like to add or remove if you had the opportunity?

00:09:56:16 - 00:10:06:20

Deolinda

Maybe if it were possible to pick up the sphere, I don't know. I think it would be interesting. To be able to control it.

00:10:06:22 - 00:10:18:10

Catarina

Like you do with the lines?

00:10:18:10 - 00:10:18:12

Deolinda

Yes.

00:10:18:12 - 00:10:47:10

Diogo

I don't know. Now an idea came to me, of some specific movement, like how it happens during the day, there's this transition from day to night? These cycles caused by a specific movement. I don't know, that idea came to me. But yes, I don't think it would add much more.

00:10:47:12 - 00:10:55:13

Catarina

That's it, thank you. The feedback was very valuable. I think it's important, and I hope you enjoyed it.

Appendix F - User Test form responses, second group

July 13th, 2023 - Google forms for User-Test quiz response from Diana and Tomás

Qual a tua relação/Experiência na área da Dança/Artes Performativas?

Diana: Já obtive contacto com bastantes vertentes inseridas no núcleo relacionado á dança, sendo as mais presentes contemporâneo e danças urbanas. Contudo, nunca com nada relacionado á experiência que obtive ou outras áreas no universo artístico.

Tomás: Tive no ensino especializado em dança 6 anos, participo em alguns projetos e agora estou a tirar a licenciatura na Escola Superior de Dança.

O que é que sentiste ao visualizar o espaço virtual? Como é que este te inspirou?

Diana: Senti a sensação de entrada numa nova realidade, num autêntico videojogo: como se de um personagem me tratasse, apesar de tomar as minhas decisões. Apesar deste último fator, levei a experiência como uma ausência de controlo do meu corpo, sendo este dominado pelo mundo virtual.

Tomás: Inspirou pelo simples facto de parecer que estou noutro sitio, não dentro de um estúdio e inspirou me principalmente os rastos de luz feitos pelos comandos.

Explica o conexão que sentiste com o espaço virtual. Focaste-te em alguma interação em particular? Porquê?

Diana: Senti-me conectada com todos os objetos e paisagem existentes visto que, todos eles, me trouxeram estímulos divergentes, impossíveis de serem ignorados. A conexão que senti terá sido então manipuladora, uma vez que o espaço me consumia e áquilo que eu pudesse eventualmente gerar.

Tomás: Nos rastos de luz emitidos pelos comandos porque se calhar é algo menos comum e algum que nao conseguimos fazer.

Sentiste-te livre? Quão diferente a exploração do movimento em Realidade Virtual em comparação aos métodos convencionais?

Diana: Naturalmente senti-me bastante mais limitada, inicialmente por não ser uma zona confortável. Numa fase mais avançada sinto que os receios do espaço reduzido e de, com o uso dos óculos, mais reduzido mentalmente se tornava, não me terão permitido á exploração total possível e claro, o tempo delimitado para a atividade.

Tomás: em comparação à realidade nao me senti mais livre.

Sentiste-te capacitado de explorar o teu movimento? Encontras-te limitações? Quais?

Diana: Naturalmente fora da nossa habitual realidade terei sentido uma determinada incapacidade na produção de movimentação. Não só a limitação mental de estar numa zona desconfortável, mas também o espaço e os objetos possuírem um controlo bastante específico e serem em grande quantidade me terá captado muito á atenção, deixando por vezes levar-me pela descoberta desses mesmos controlos, não construindo material com grande qualidade coreograficamente.

Tomás: as limitações que encontrei foi o equipamento em sim, os oculos e os comandos.

Necessitavas de estar sempre concentrado no ambiente virtual? Porquê?

Diana: Pessoalmente sinto que não poderia concentrar-me em qualquer outro aspeto, uma vez que a quantidade de interações disponíveis e os seus controlos me obrigavam a prestar atenção nisso mesmo, para que imagens interessantes através daí me levassem a movimentos igualmente relevantes. Sendo assim, em nenhum momento me preocupei com fatores externos tendo procurado, ao invés, que esses mesmos fatores se adaptassem a mim.

Tomás: Quando estava focado em alguma coisa no ambiente nao era preciso estar no resto.

Como foi a experiência de ver os teus movimentos projetados no espaço virtual? Serviram apenas de representação do teu movimento ou também como inspiração para o mesmo? Porquê?

Diana: Penso que funcionavam nas duas vertentes referidas uma vez que, mesmo no quotidiano, aquilo que produzimos acaba por se revelar, mais cedo ou mais tarde, fruto de inspiração para uma outra tarefa. Não há uma justificação específica, é apenas como o ser humano funciona: através das sensações que possuímos, captamos essa informação e decidimos o que fazemos com ela, inspirando-nos para fazer igual, melhor ou não seguir esse mesmo caminho.

Tomás: serviram de inspiração tambem porque o movimento criava movimento no ambiente e esse movimento no ambiente inspirava me mais.

O que alterarias neste protótipo? Porquê?

Diana: Não alteraria a forma como está construído apenas, com mais tempo, construir ainda mais objetos atribuídos com ações do corpo, talvez provindas de outras partes não tão utilizadas nesta experiência, como as pernas ou até o tronco.

Tomás: o que alteraria era o equipamento para poder explorar ao máximo.

Como visualizas uma versão final deste projeto? Que características e funções esperarias encontrar?

Diana: Reforço a questão a que respondi anteriormente, com tecnologia que invade todo o nosso corpo, com uma variedade de controlos, confusos para o cérebro, mas que para o corpo não são precisos de serem compreendidos.

Tomás: uma das funções que iria encontrar era levar a imagina e a inspiração muito mais alem.

Tendo o acesso á mesma, que uso darias a esta ferramenta? Porquê?

Diana: Obviamente, para a construção de uma peça. Não iria querer esconder todo o material tecnológico, para que o público pudesse realmente visualizar todos os detalhes de como essas talvez restrições funcionam no corpo humano. No entanto, não transmitiria numa tela a visão do bailarino, deixando a mente do espectador especular nesse mesmo aspeto. Tudo isto em tempo real, existindo apenas pequenas instruções que apenas seriam reveladas no próprio espetáculo, durante a performance, recebidas pelo bailarino através de um auricular.

Tomás: para coreografar

Form Questions and anwers translated using ChatGPT

What is your relationship/experience in the field of Dance/Performing Arts?

Diana: I have had contact with various aspects within the dance field, with contemporary and urban dance being the most prominent. However, I've never had an experience like the one I had here or in other areas within the artistic realm.

Tomás: I had 6 years of specialized dance education, have been involved in some projects, and I'm currently pursuing a degree at the School of Dance.

What did you feel when viewing the virtual space? How did it inspire you?

Diana: I felt the sensation of entering a new reality, like being in a video game: as if I were a character, even though I made my own decisions. Despite this, I experienced a lack of control over my body, as it was dominated by the virtual world.

Tomás: It inspired me simply because it felt like I was in a different place, not inside a studio, and I was particularly inspired by the light trails created by the controllers.

Explain the connection you felt with the virtual space. Did you focus on any particular interaction? Why?

Diana: I felt connected to all the objects and the landscape since they all provided me with diverse stimuli that were impossible to ignore. The connection I felt was therefore manipulative, as the space consumed me, and whatever I could potentially create.

Tomás: I focused on the light trails emitted by the controllers because it's something less common and something we can't easily do.

Did you feel free? How different was the exploration of movement in Virtual Reality compared to conventional methods?

Diana: Naturally, I felt much more limited, initially because it wasn't a comfortable area. In a more advanced stage, I felt that the fear of the confined space and the mental limitations caused by wearing the glasses didn't allow me to fully explore. Additionally, the limited time for the activity also played a role.

Tomás: Compared to reality, I didn't feel more liberated.

Did you feel capable of exploring your movement? Did you encounter limitations? What were they?

Diana: Naturally, outside of our usual reality, I felt a certain inability to produce movement. Not only was I limited mentally by being in an uncomfortable zone, but also the space and the specific control of numerous objects captured my attention, sometimes leading me to explore these controls instead of creating high-quality choreographic material.

Tomás: The limitations I encountered were related to the equipment itself, the glasses, and the controllers.

Did you always need to stay focused on the virtual environment? Why?

Diana: Personally, I felt that I couldn't concentrate on anything else since the numerous available interactions and their controls required my attention. I had to focus on them to create interesting visuals that would lead to equally relevant movements. Thus, I didn't worry about external factors and instead tried to make those factors adapt to me.

Tomás: When I was focused on something in the environment, I didn't need to be focused on anything else.

How was the experience of seeing your movements projected in the virtual space? Did they serve only as a representation of your movement or also as inspiration for it? Why?

Diana: I think they served both purposes, as what we produce eventually becomes, sooner or later, a source of inspiration for another task. There isn't a specific justification; it's just how humans function: through the sensations we experience, we absorb that information and decide what to do with it, whether it's to inspire us to do the same, better, or take a different path.

Tomás: They also served as inspiration because the movement created motion in the environment, and that motion in the environment inspired me further.

What would you change in this prototype? Why?

Diana: I wouldn't change the way it's built; rather, with more time, I would create more objects with body-related actions, perhaps from less commonly used body parts in this experience, such as the legs or even the torso.

Tomás: What I would change is the equipment to enable maximum exploration.

How do you envision a final version of this project? What features and functions would you expect to find?

Diana: I reiterate the answer I provided earlier, with technology that encompasses our entire body, with a variety of controls that may be confusing to the brain but not necessary for the body to understand.

Tomás: One of the functions I would expect is to take imagination and inspiration much further.

If you had access to it, how would you use this tool? Why?

Diana: Obviously, I would use it for creating a piece. I wouldn't want to conceal all the technological aspects so that the audience could truly see all the details of how these restrictions might function in the human body. However, I wouldn't convey the dancer's view on a screen, leaving the spectator's mind to speculate on that aspect. All of this would be in real-time, with only minor instructions revealed during the actual performance, conveyed to the dancer through an earpiece.

Tomás: I would use it for choreography.

Appendix G - Nabia Download Link and User Test Videos

Link:

https://drive.google.com/drive/folders/1KKKuVpLi3sLIwKc8EhmM86ndgmCdBn55?usp=sharing