# A Cloud gaming platform

*Redesigning desktop application for VR environment*

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Interaction Design Project 3 titled "A Cloud Gaming Platform: Redesigning Desktop Application for VR Environment" By Rajdeep Sutradhar (Roll Number 22M2251) is approved for partial fulfillment of the requirement for the degree of 'Master in Design' in Interaction Design at the Industrial Design Centre, Indian Institute of Technology, Bombay.

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# A Cloud gaming platform : Redesigning desktop application for VR environment

Rajdeep Sutradhar | Prof. Girish Dalvi (IDC) | Piyush Sharma (Nvidia)

## Abstract

This project explores the intersection between the domain of cloud gaming platform and its adaptation for the Virtual Reality environment. Cloud gaming offers the convenience of playing high end games without owning an expensive computer setup, players can stream the processing power from a service into whatever device they are using. In this project, we aim to explore extending this into the VRscape. Project was scheduled into a span of three months where the scope was to visualise, prototype and evaluate the most frequently used screens of the platform (Home page, Game library page, evidence page, game screen and In-game overlay).

### Keywords

Cloud gaming, spatial interface design, 3d navigation, VR

## 1. Introduction

Cloud gaming as an industry is growing at a pace never before. Gone are the days when we were required to use high end local computers with expensive GPU hardware to play good graphics games. Cloud gaming is a service where an enterprise provides the infrastructure to host such game sessions and users can just directly stream the game over the internet.
In order to get a proper perspective about the VR space as a designer I explored the device (Quest 3) and compiled a brief auto - ethnographic description of my spatial experiences of the virtual space.

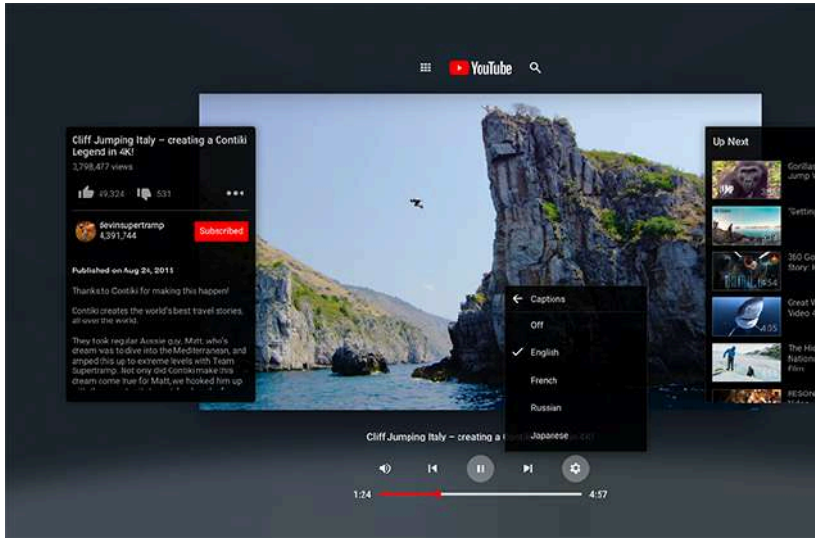
**Spatial Experience in Virtual reality Environment**

### 1.0 Scale boom

#### 1.1 Scale of the interface changes drastically,

- The UI elements that we see usually are confined to screen size, but here they were as big as my body.
- Like the theatre mode in youtube or watching any video is exactly like watching a movie in a theatre.
  The awe in this is the speed of transition, it almost feels like teleportation to a cinema hall. The same experience with a click. It's almost as if I got a mental push by the content itself that I just turned on, saying "sit back and enjoy".
  I experienced the scale and environment of a movie theatre sitting on a couch or travelling in a metro.

- Experiencing that scale, in spaces where it might not be physically possible in the real world is what makes it amazing. And We need not talk about the customizability. There are a whole lot of options




### 1.2 VR enabled videos

- While 360 degree experience felt overwhelming at a lot of times, because it was just a lot to focus on. Felt like I was missing something almost all the time, especially when I was looking at a 360 degree recorded video. I do not want to miss out on anything the director wants to show. Hence constantly turning my head round and round gave me a little bit of dizziness. **

Associated keywords: *Grandness, vast, theatrical, atmospheric, overwhelm*

## 2.0 The added Dimension

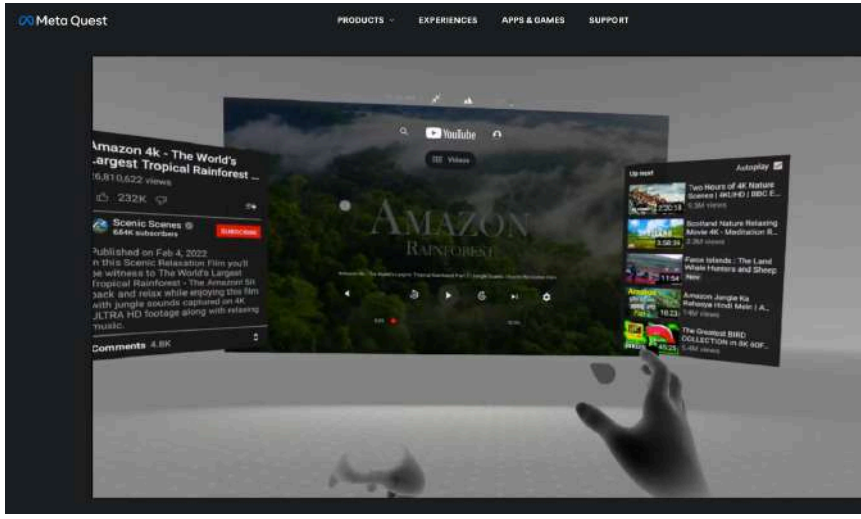
### 2.1 Resemblance to real work physics & interactions

- The screen based display of components got a new dimension, which is depth. Everything seems to have become more alive / more real.

I can see elements stack over each other, some overlap, one's shadow on the other,raytracing, parallax when elements have relative movement, it's all complying and resembling more to the real world.

  - **Idea / Could have/ missing:** Could involve enabling other real life interactions like sliding stuff, and elements would possess inertia. Like if we push it accelerates down a path before coming to rest. Assigning weight to elements. (If we are doing glass morphism, the element should behave like glass in terms of classical physics)

- **Example:** Youtube- Comments panel, video controls, Next in line are three different panels floating on top of the video.




### 2.1 Reduced metal load (Cognition) due to better hierarchy

- Hierarchy was better perceived, while navigating through the interface. I could easily feel the difference in mental load in terms of cognition, because if I am looking for something, I do not have to

look into the same plane, components are grouped and divided into clusters. It makes it much easier.**

**Associated keywords:** *Refreshing, newness, easier cognition, reduced mental load, hierarchy*

## 3.0 The Urge to Touch

### 3.1 Tactile desire to play with UI elements

- As soon as the new dimension was added and interface elements were perceived to be more real and alive, I constantly felt the urge to touch and feel , and pick up stuff fiddle with them just like we do in the real world.
- When we see a device like a radio, we take it in our hands, look at it, touch the buttons, try out what they allow us to do, experiment and explore it with almost all our senses.
  That's what I think designing immersive interface / experience would envision in the upcoming years

### 3.2 Co-existing with virtual elements

- Till now we were passively engaging with the interface elements through buttons or trackpads or keyboards. Screen elements and human beings were in different worlds.
  And suddenly me and UI elements are in the same space / environment. Or at least I have a pair of hands that exist in the same space as the UI does.

**Associated keywords:** *Haptic desire to interact, urge to touch, tactile feedback*

## 4.0 Hands in a glove box

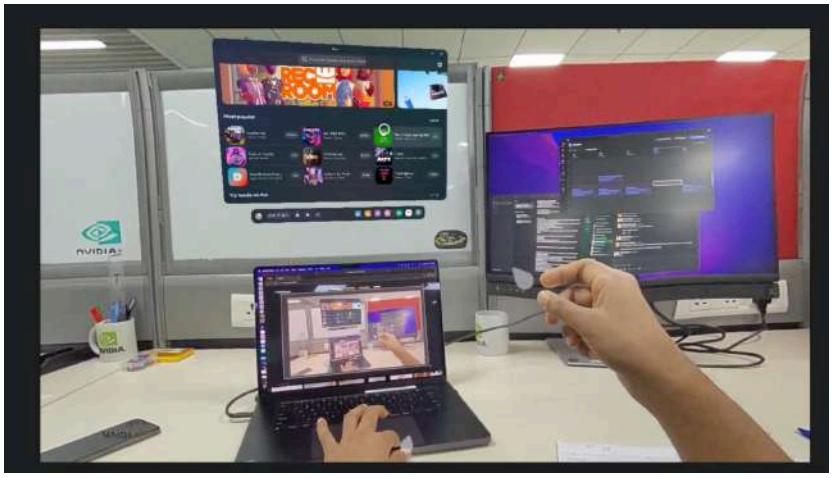
### 4.1 Body feels safe even when dealing with dangerous stuff

- The closest metaphor I associated with the phenomena of seeing my hands in the VR space was that of a glove box. My body is out of the space but my hands are inside within a pair of gloves, I can manipulate the elements inside and I see the live feed of what's happening inside.
  Like the glove box allows you to handle/ experiment hazardous stuff, in real time with your own hands, VR also allows you to shoot guns, do dangerous things with your own hands while you are in your safe space.

*Source : Google Archive*

### 4.2 Feels weird due to latency mismatch

- The quest regenerates / re-renders my hands in the VR space for some apps like Youtube VR. It presents like a pair of dark grey gloved hands. It tracks the hand almost close to the real world. But that is not totally accurate. And due to the latency the brain encounters a mismatch due to which the experience feels a bit weird.

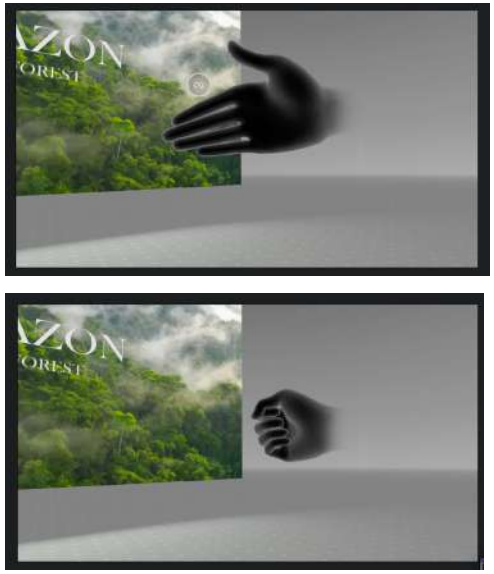






**4.3 Anomaly in hand representations**

- Trying out different gestures leads to a lot of glitches in rendering objects that overlap, for example when we make the namaste gesture it's confused and renders fingers intersecting one another.
  When I bundle my fingers into a fist, the fingers represented on the screen are still not touching each other, and I try to tighten my grip further to see the changes.
- Even if there is no overlay on my hands one observes a lag in the movement and the footage.



**Associated keywords:** *Gestures representation, Latency in visuals, glove box*

## 5.0 Multisensory experience

### 5.1 Effects due to Conflict in senses

- Since our brain perceives it as a multisensory experience, there is a huge conflict between senses.
  Our Vision and audio is overloaded with stimulus within the VR environment with a lot of movements and motion, but other senses are stationary, they do not have any stimulus at all.
  Hence symptoms like **VR / cyber sickness, motion sickness** ***Causing disorientation, dizziness, sweaty, nausea***

  **Instance from felt experience** : I felt the effect at the maximum intensity when I performed a jump in the game. I felt my feet bracing for impact, and I pressed my feet hard against the ground in the real world when I landed from the jump in the game.
  Eventually, I felt the effect when running and my view was panning fast.
  Also it's heightened due to poor game design also, because I had to turn my head with Joystick. Whereas the more intuitive way to go about it is, it should be able to track my head movement and pan accordingly.
  - ***Upcoming tech research around this :*** *Vestibular stimulation technology: Stimulates the fluids in the inner ear, matching to what stimulus is received in visuals.*

## 6.0 Controllers vs hand gestures

### 6.1 Use cases are highly contextual

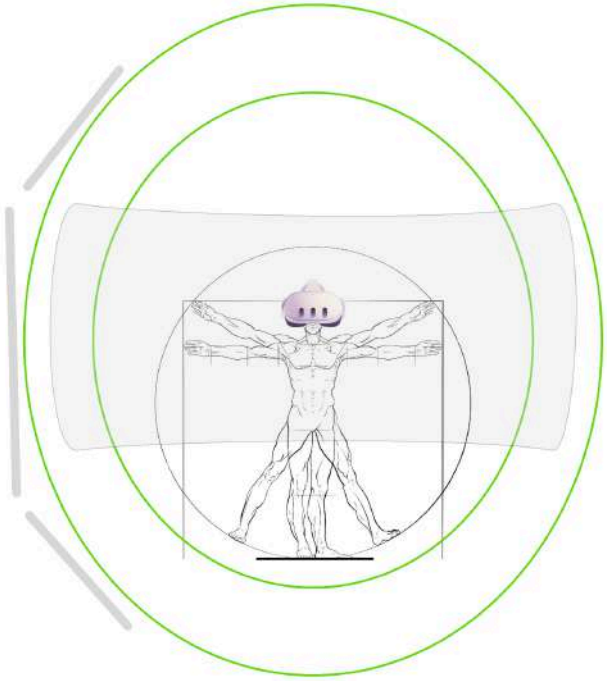
- While playing a game, mostly we have to use controllers, hand movements and gestures are not tracked there. I felt Controllers are mostly designed keeping the games with guns in the centrepoint. The ergonomics of the controller is exactly like holding the handle of a gun. It has triggers at the front, angle of the handle, area for thumb operations, everything aligns to the design of a gun.
- However this controller does not feel very intuitive when we are navigating in the general interface as there is no real world resemblance to the actions we are doing there. So, controllers felt relevant while playing gun related games and hand tracked control felt more intuitive while navigating the general interface.

- But Unfortunately the controllers are more crispier and accurate at tracking and hence felt easier mode than hand gestures to interact with the interface.

## 7.0 Nature of spatial form / Volume

### 7.1 The layout is arranged in a way that it surrounds us

The interface is designed in such a way that it feels like I as the user is at the centre point. Even if there are multiple parts to the displayed interface, the normal of each element points towards me. Feels like a control panel of a ship, with me on a rotating chair.



Hence most of the interactions are in rotational motion and hence the layout is an extension of the natural anthropometrics of a human body (eg. arc traced by our arm as the radius)
And it's not in circles but a spherical extension, the azimuth angle and tilts are similar.
I felt it's a little more oval shaped than perfect concentric circles / spheres.

### 6.2 Anchoring

The elements have different anchoring points like some windows are anchored to the environment and some are anchored to the user's body. This mimics real world use cases such as construction workers, where the tools which are heavy and less used are kept in a storage and tools which are frequently required and small are kept attached to the body garment itself.

# 2. Literature study

In this we are looking at an intersection of VR and cloud gaming as an upcoming opportunity area for the market. Hence it is important to understand the fundamental principles when it started and its progression to what we have in the present day.

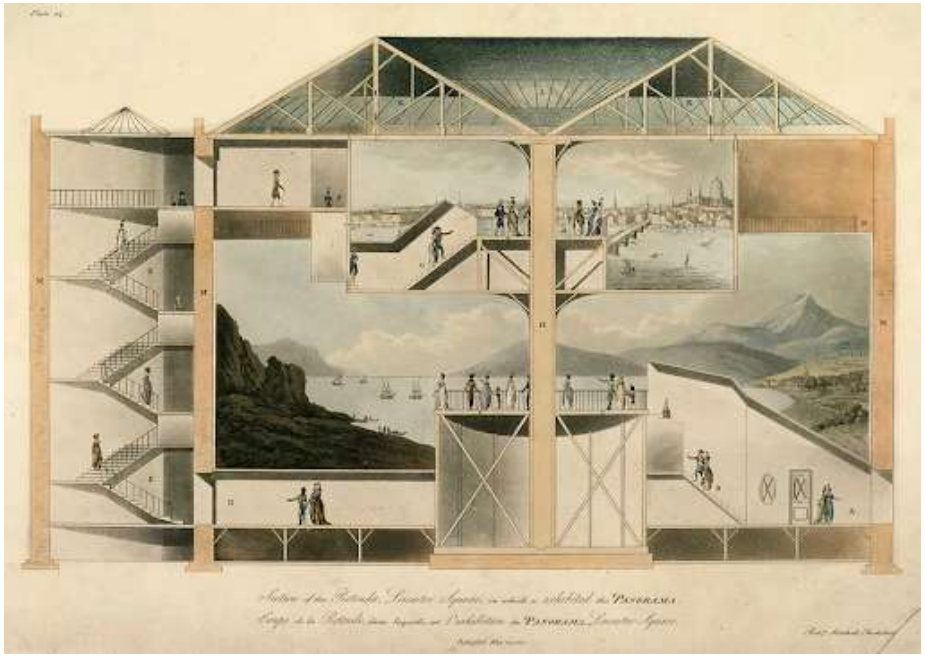
### 80 BC : Roman fresco murals of the "Second Style"

These were essentially wall paintings "meant to provide the viewer the sense of being in the place or event depicted"
To create the sensations of being immersed wholly in another place

*Source : Cubiculum (bedroom), Villa of P. Fannius Synistor at Boscoreale, 50–40 B.C.E., fresco (The Metropolitan Museum of Art)*
*https://smarthistory.org*

**1787 : Robert Barker "The Panorama"**

Through the volume and viewing distance they tried to create an experiential environment. It was an attempt to fully immerse the audience in the scene.



*Source : Cross section of Robert Barker's two-level panorama rotunda in Leicester Square (1793)*
*https://medium.com/@bange/1787-173e223fe1ac*

This was the period when the word immersion started coming up and was used by a lot of entertainment design architects and visualists. It was derived from the word Immergere Meaning 'Dip into' some liquid and in the context of entertainment media it is used as a Metaphor as a Deep mental involvement in something.

*Source : https://www.behance.net/gallery/106988987/Underwater-Study*

**1838 : Charles Wheatstone's Stereoscope**

Creating the illusion of 3D from flat images using small changes in angle of photo captured. To create a sense of depth from 2d images of shifted vanishing points.

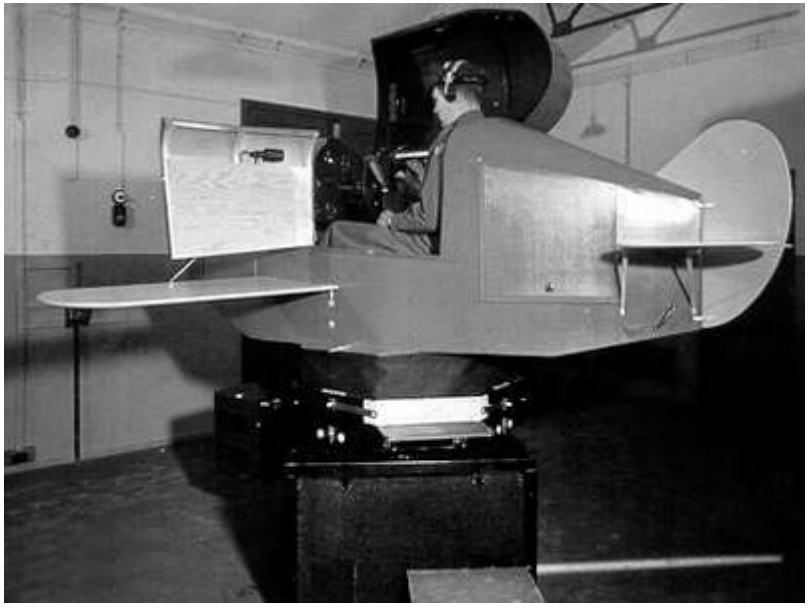
*Source : https://www.kcl.ac.uk/charles-wheatstone-the-father-of-3d-and-virtual-reality-technology-2*

**1929 : Link's Flight Simulator**

This simulator allowed the pilots to train and have an accurate representation of how it really feels to control a plane.

**Input > Response**

This was the first time immersion was including Physical movement (Not focusing on Oculocentric experiences).



*Source : https://en.wikipedia.org/wiki/Link_Trainer*

**1939 : View-Master**

This play device was conceptualised as an upgrade to the Already existing stereoscope. The Novelty was in the form, a very portable headset.


*Source : https://www.doyouremember.co.uk/memory/view-master*

**1962 : Heilig's Sensorama**

The device sat in arcades which included a stereoscopic colour display, fans, odour emitters, stereo-sound system, and a motional chair. Multisensory (Motion, air, sound, smell) experience.


*Source : https://www.doyouremember.co.uk/memory/view-master*

**1968 : The Sword of Damocles**

"Ultimate display" A room within which the computer could control the existence of matter. Virtual environment for the first time. Head tracking / anchoring position in the virtual space (Done mechanically).

*Source: https://www.researchgate.net/figure/Sword-of-Damocles-Sutherland-1968_fig4_356638451*

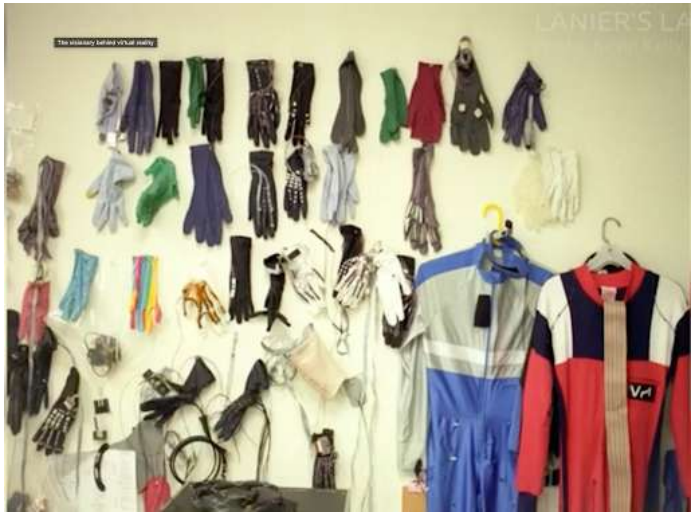
**1974 : Myron Krueger builds an artificial reality lab Videoplace.**

An independent scientist named Myron established the lab to allow people to communicate in "artificial reality" without gloves that would track movements. This was the first time we could learn to interact with the virtual elements.


*Source : https://makeagif.com/gif/videoplace-1985-rOsWq9*

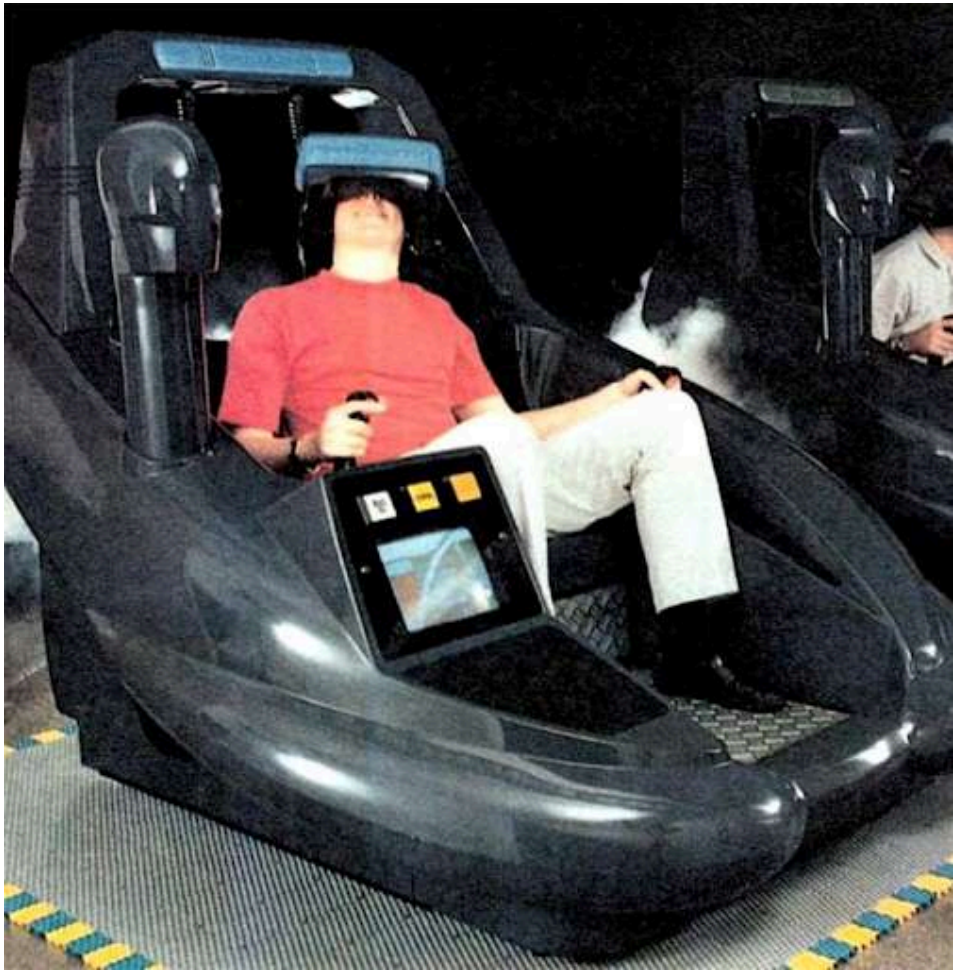
**1985 : The name Virtual reality" is officially born (Jaron Lanier starts selling VR products)**

Putting users multiple into a simulated world, where they interacted with each other. It was derived from the idea of painters to depict the universe as different from the actual one we live in. A social space where people turn into bodies and creatures and meet each other.



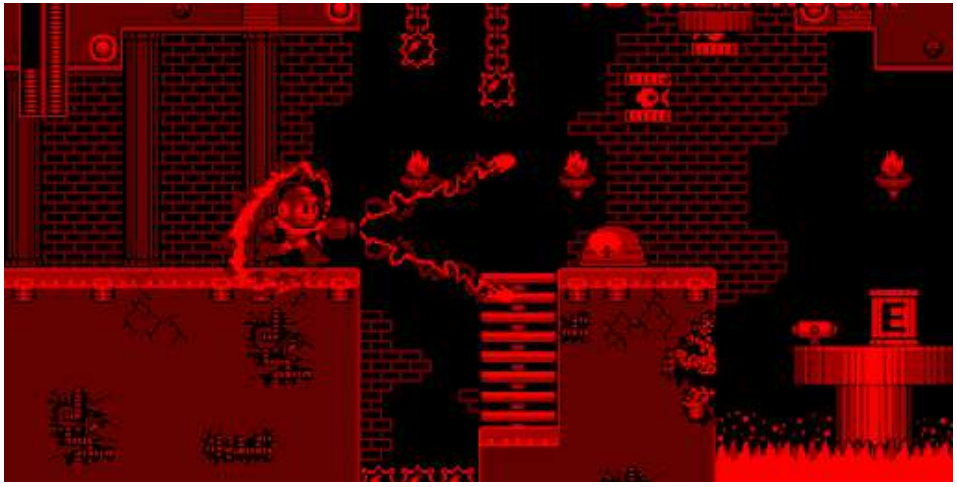
*Source : hhttps://www.bbc.co.uk/ideas/videos/the-visionary -behind-virtual -reality /p05tf380*

**1990 :** Tom Caudell introduces augmented reality to guide airport field workers. In the same year VR arcade machines that can be found at video game centres.



*Source : Google archive*

**1995 : Nintendo'S VIRTUAL BOY** was released but had to shut down due to extensive strain on users' eyes due to the red colour.



*Source : Google archive*

**1996 : 2D markers for AR (Barcodes) were** used for the first time opening a break into the world of AR possibilities.

*Source : https://www.shakebugs.com/blog/top-mobile-augmented-reality-tools-2020/*

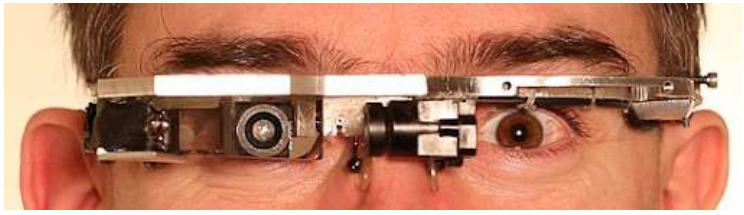
**1998 : Sportvision applies AR for the NFL game translation**

Suddenly the engagement of spectators with the game increased by many folds. Aim was to communicate information in a more comprehensible way, so that people could make out the important information instantly.


*Source : https://en.wikipedia.org/wiki/1st_%26_Ten_%28graphics_system%29*

**2000 : Eye tap**

MNC's like google and Microsoft started exploring devices like these which Augmented computer graphics on the eye. Like the modern day Hololens.



*Source : https://en.wikipedia.org/wiki/EyeTap#/media/File:MannGlassEye1999crop.jpg*

**2007 : Sony playstation eye**

The camera placed above the display could recognize body postures and use it as an input for the video game. This was the first time there was bodily input being used as input and sold as a product in the market.


*Source : https://en.wikipedia.org/wiki/1st_%26_Ten_%28graphics_system%29*

In the subsequent years we moved onto 6 degrees of freedom from 3 degrees of freedom, which meant that now virtual objects could be anchored to the virtual environment with respect to our body position.

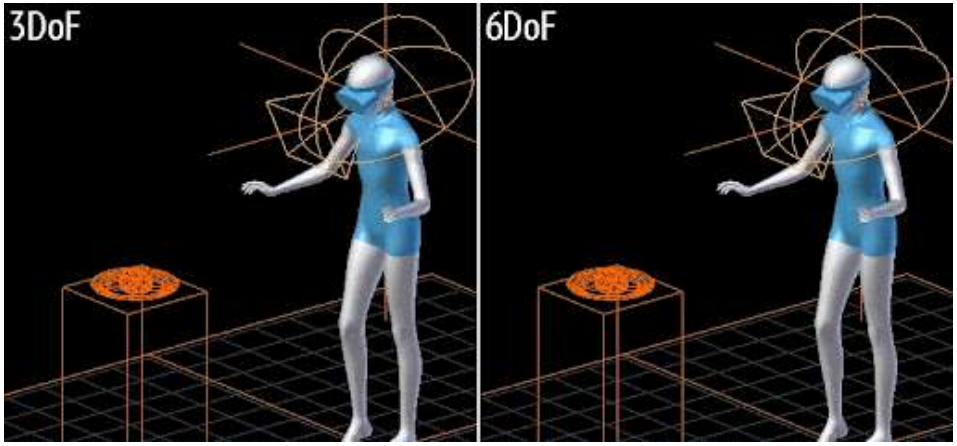
**2012 : Oculus VR**

**2014 : Google's cardboard**

**2016 : Sony Playstation VR + Hololens**

**2023 : Quest 3**

And the technology became more and more accessible in terms of fine tuning as per user needs and making it more affordable.

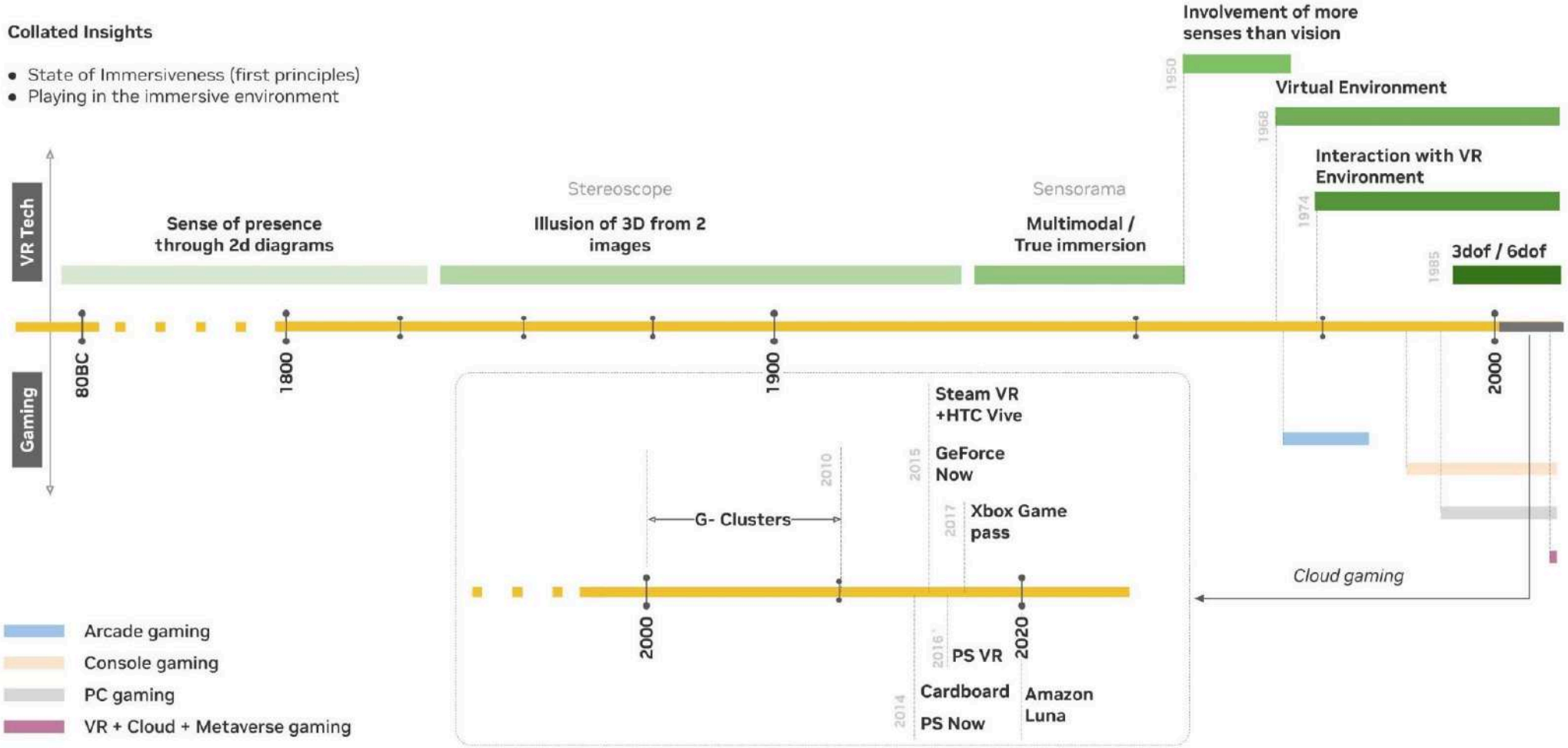



*Source : https://en.wikipedia.org/wiki/1st_%26_Ten_%28graphics_system%29*

**Insights**

After drawing out a timeline of virtual reality as a technology, in order to see it alongside the context of gaming and its adoption of cloud technology, the timelines of the two were visualised and summarised in the form of a diagram.

In the diagram the upper side of the timeline shows the evolution of VR technology and the bottom part denotes the evolution of digital gaming technology. Cloud gaming technology is relevantly very new as we can see that it started around the starting of last decade (shown in a timeline separately at the bottom half of the page).


Collated Insights
State of Immersiveness (first principles)
Playing in the immersive environment
VR Tech
Gaming
Sense of presence through 2d diagrams
Stereoscope
Illusion of 3D from 2 images
Sensorama
Multimodal / True immersion
Involvement of more senses than vision
1950
Virtual Environment
1968
Interaction with VR Environment
1974
3dof / 6dof
1985
80BC
1800
1900
2000
Steam VR +HTC Vive
2015
GeForce Now
2010
G- Clusters
2017
Xbox Game pass
Cloud gaming
2000
2016
PS VR
2020
2014
Cardboard
PS Now
Amazon Luna
Arcade gaming
Console gaming
PC gaming
VR + Cloud + Metaverse gaming

**Demographic Outlook**

The primary demographic interested in Virtual Reality (VR) devices is the 18-35 age group, with a notable majority of men showing intent to purchase VR systems. The predominant user group is the gaming  and entertainment media community to adopt and use the tech in mass production. (40.5% of the market). However, VR is gaining traction increasingly in the Education, Health care and enterprise training industry.

**Gender distribution :** People who intend to purchase VR devices, 69% are men and 31% are women (Mirrors the stats of the current gaming industry).

**Existing gamers :** Traditional PC or console gamers who are curious about VR experiences.

**Simulation enthusiasts :** Flight, racing, or other simulation games that benefit from VR immersion

**Social gamers:** People who enjoy online multiplayer games and might appreciate social VR interactions

**Occupation:** Tech-savvy individuals, gamers, early adopters of technology.

**Income:** Individuals with income to afford VR headsets and potentially pay for cloud gaming subscriptions.

**Trends in VR technology**

A 15% increase from 64 million in 2022 to 2023 was observed in the number of VR users. Cloud gaming is projected to expand at a compound annual growth rate (CAGR) of 48.2% from 2021 to 2027 (Source) and 24.2% for VR market from 2021 to 2028 (Source). Obstacle to wider VR adoption (Perkins coie survey\). Technical glitches, bugs, and bulky headsets are the primary deterrents to a higher VR adoption rate. According to survey participants, there's a lack of quality content (20%) in VR products. 49% of respondents mentioned health-and-safety issues as obstacles. Licensing difficulties and potential third-party copyright infringement were mentioned by 32% and 30% of those interviewed.

**What is the delta in the gaming experience in VR when Compared to Non-Immersive Video Games?**

Immersion and engagement with the game environment is the key differentiator. 3D interaction and natural intuitive movement : Interacting using one's own body itself as against controlling with buttons. Enhanced field of view creates a more realistic sense of space. Some VR experiences also include senses more than audio visual, like vibro-tactile feedback.

**Physiological and Psychological effects**

**Positive [1]**

- Playing in the immersive display modality was associated with higher self-reported happiness and surprise.
- The perceived sense of presence was observed to be higher in the virtual reality condition.
- Players showed a more intense emotional response (arousal of senses), reported through physiological changes (heart rate and skin conductance).
- VR has been successfully used to treat psychological problems like social anxiety, fear of flying, post-traumatic stress disorder, and fear of heights.

**Negative**

- Nausea (motion sickness) is the most experienced disorder while using head mounted displays. However it varies from person to person.
- Early VR headsets were associated with headaches, eye strain, and dizziness.

**SWOT analysis for market viability of the product**

**Strengths**

- Leveraging Existing User Base: GeForce Now boasts a large existing user base familiar with the platform and potentially receptive to VR adoption.
- Technical Prowess: Nvidia's expertise in graphics processing and cloud technology positions them well for VR implementation.
- Partnerships: Potential collaborations with VR hardware and software developers could expand content offerings and user reach.
- Subscription Model Integration: Seamless integration with the existing subscription model offers cost-effective VR access for users.
- Performance Optimization: Nvidia's focus on high-performance cloud gaming could translate to a smooth and immersive VR experience.

**Weaknesses**

- Limited VR Game Library: GeForce Now needs to build an elaborate library of VR-compatible titles.
- Potential Hardware Limitations: Streaming high-quality VR graphics might require upgrades to Nvidia's server infrastructure, impacting costs.
- Subscription Cost Increase: Adding VR support might necessitate a subscription price increase, potentially deterring some users.
- VR Headset Reliance: Users still require compatible VR headsets, creating an additional cost barrier.
- Competition: Established VR platforms and other cloud gaming services with VR offerings pose significant competition.

**Opportunities**

- Growing VR Market: Capitalising on the projected VR market growth can attract new users and expand the platform's reach.
- Exclusive Content Partnerships: Securing exclusive VR game deals could entice users and differentiate GeForce Now from competitors.
- Subscription Bundles with VR Hardware: Bundling VR headset subscriptions could incentivize adoption and address hardware accessibility concerns.
- Artificial Intelligence
- Integrating AI : Can help users adapt to the VR environment based on user behaviour and preferences, making it more engaging and intuitive.
- Exploring Metaverse : Designing arcade / game hubs in the metaverse can be a lucrative venture.

**Threats**

- Negative Publicity about VR Health Risks: Unfounded concerns about VR's impact on health could deter potential users.
- 49% of respondents mentioned health-and-safety issues as obstacles (Perkins coie survey)

- Data Privacy Concerns: Balancing user data collection for personalization with privacy regulations.

**Ethical concerns**

**Culture**

- Can we accurately reflect / represent / celebrate diverse cultures and identities?
- Could the cultural element we use be an insensitive appropriation?
- How might VR experiences influence users' perceptions with different cultures?

**Security and data privacy**

- How is user data collected and used in VR games? Are users informed and will GFN interfere here?
- Can GFN VR adequately protect user data from hacking and cyber attacks?
- Are users being monitored within VR environments? Who has access to this data?

**Tolerances**

- How / will GFN prevent the spread of hate speech and discrimination within virtual spaces?
- Could the immersive nature of VR games lead to addiction or negative psychological effects in some users?
- How will GFN VR negotiate with the portrayal of violence, and could this desensitise users to real-world violence?

**Regulation and Punishments**

- Do existing laws and regulations adequately address the unique challenges of VR gaming?
- What types of punishments should be implemented for online misconduct or criminal activity within VR environments?

**Knowing the device of focus**

In order to define the context of where the digital product is going to be used it was important to choose and scope the project according to a certain ecosystem of technological premise. In this case some of the most sold / popular products were selected and put down on a comparison matrix. Where they are compared against each other based on following parameters :

- User Base (Number & Type)
- Design Requirements of the operating system
- USP of the product
- Limitations
- Usability concerns

Based on the discussions with stakeholders and the product team the Quest 3 was chosen to be the base device to start with.

| Devices / Parameter for comparison | Google cardboard | MI Hololens | Playstation VR | HTC Vive | Quest 3 | Vision Pro |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| **User Base (Number & Type)** | • Millions (casual users, budget-conscious) | • Tens of thousands (professionals, enterprise users) | • Tens of millions (PlayStation owners, gamers) | • Hundreds of thousands (enthusiasts, PC gamers) | • Millions (gamers, general VR users) | • Limited (early adopters, professionals) |
| **Design Requirements** | • Simple, low-poly graphics<br>• Limited interaction options<br>• Focus on 360° experiences | • Design for hands-free interaction<br>• Utilize spatial mapping and object recognition<br>• Consider enterprise applications | • Leverage PlayStation controller<br>• Consider VR sickness potential<br>• Design for gamepad or motion controls | • Design for room-scale VR with tracked controllers<br>• Focus on high-fidelity graphics and immersive experiences | • Design for standalone operation, consider hand tracking and voice interaction<br>• Balance processing power with battery life | • Design for high-resolution visuals and advanced features<br>• Consider eye tracking and complex interaction possibilities |
| **USP** | • Most affordable VR option<br>• Easy to use and accessible | • Powerful features, hands-free interaction<br>• Suitable for enterprise and professional use | • Large user base, established gaming platform<br>• High-quality visuals and immersive experiences | • Room-scale VR with high-fidelity graphics<br>• Wide range of content and experiences | • Standalone operation, hand tracking and voice interaction<br>• Wide range of apps | • Cutting-edge technology, high-resolution visuals<br>• Advanced features like eye tracking |
| **Limitations** | • Low-quality visuals and limited interaction<br>• Requires smartphone<br>• Not ideal for extended use | • Expensive, bulky, requires tethered connection<br>• Limited app availability | • Tethered to PlayStation console<br>• Limited room-scale tracking<br>• Primarily for gaming | • Expensive, requires powerful PC and setup space<br>• Complex setup process | • Limited processing power compared to PC VR<br>• Battery life concerns | • Expensive, limited availability, complex setup<br>• Limited app library |
| **Usability** | • Very easy to use, minimal setup | • Moderate learning curve, requires understanding of hand gestures | • Easy to use with PlayStation controller, potential for VR sickness | • Moderate learning curve, requires setup space and powerful PC | • Easy to use, standalone operation | • Complex setup, requires understanding of advanced features |

## 3. User study

An user study was conducted to better understand users. A protocol was basically a  one to one discussion with participants while they experience VR, navigate through different types of interfaces, understand affordances of using the headset etc. And the Estimated time was around 30-45 mins.

**Sample screening**

- Familiar to VR experience (3 participants)
- New to VR experience (3 participants)

**Experiment plan**

- Approach through slack, Self introduction
- Screening questions (familiarity with VR)
- Invite for the discussion if qualified
- Start recording
- Concurrent enquiry (Ask questions while they are doing it)
- Ask for general feedback

**Setup**

- Participant physically present
- Connected over teams
- VR casting on chrome
- Screen shared on teams
- Discussion recorded on teams.

**Data Collection**

- Recorded voice clip
- Screen recording of VR cast
- Observation notes

**Data analysis**

- Transcription of the voice clip
- Thematic analysis > Insights
- Observe casting recording
- Draw insights

**Ethical consideration**

- Take consent before recording
- Specify beforehand that they can remove the headset if at any point of time they feel uncomfortable

**Script design for the conversation**

**Introduction and onboarding**

Participant wears the headset and has controllers

**Prompt :** I want you to explore the interface as you wish. You can open the app library and explore the apps. Switch between immersive mode, pass through, curve vs flat screen.

**Questions :**

- Have you ever used virtual reality (VR) before? If yes, how frequent? Average runtime?
- What types of VR experiences have you had?  And which one do you think is best suited for Vr experience (e.g., Games, Simulations, Social experiences)

**Intent :** To make them comfortable within the VR environment

**Body representation and spatial awareness**

Participant switches from the controllers to hand gestures

**Prompt :** I want you to switch to the immersive mode. Observe your hands while you try doing various gestures with them (point, move your fingers, criss-cross them, hold one hand with the other). Now stand up and look into the mirror. Look at your

whole body. Now come to the pass through mode and observe your hands again.

**Questions :**

- What did you think about the represented image of your body (hands and avatar) in the VR environment?
- Any weird experience around how you felt your body inside the VR space?
- How present do you feel within the environment?
- How close do you think it is close to real life experience? Why do you feel so? Rate it in the scale of 1-10*

**UI components**

**Prompt:** I want you to go to the app library, navigate to youtube VR and play a Video (Not 360). Play it in different modes, (theatre modes). Try changing the screen size. Look at some other angle and re-centre your view, from the quick menu.

*Participant comes out of the youtube VR*

**Prompt:** I want you to switch distance, and resize the window size.

Open three tabs parallel. Youtube, browser and file explorer. Try and swap the positions. Resize the tabs. In the file window, explore the sort and filter option.

**Questions**

- How do you think the experience is different from that of viewing it on a 2d screen? Can you list some of the cons?
- What size of the window did you like the most? In terms of ease of use?
  //Explain Anchoring//
- If you had to roughly categorise some functions according to anchoring points, how would you go about it?
- Probe: (Possible Categories : Anchored to space, anchored to body, anchored to hand, etc.

**General feedback**

**Prompt:** I want you to open the settings menu and explore. Try finding out about the OS. Change brightness, Volume, Quick menu vs Full menu.

**Questions**

- Do you notice any difference in how the interface elements behave here as compared to the 2d screen.
- If you consider typing in the physical keyboard as 5/10 , how would you rate the typing in the VR keyboard?
- Confusion points faced in interface or interactions?
- What are the things that you tried but did not happen as you thought it would?
- What do you think about gaming in VR? Where do you see VR gaming in future? How interested are you to try it?

## User study insights

### General perception

Average runtime has never been more than 45 minutes, Depending on use cases. Affordability of VR is best utilised for Gaming and entertainment. Most users are optimistic about VR games. However some users highlighted that it will not be true for all types of games. Right brained people tend to appreciate the tech more than left brained.

*"Immersiveness is the magic, it feels surreal"*

### Body representation and spatial awareness

Satisfied with the response and ability to track gestures. Felt unnatural and artificial when they tried various hand gestures and fingers intersected with one another. The hands with black gloves in the Youtube app felt the most intuitive.

*"Feels like I am using plastic hands of some life size dolls"*

### User interface behaviour

People want personalisation, in terms of interface layout, and avatar.
Most striking features of the VR-

- Placement in physical work
- Size of graphics (The posters, the images you get to view in theatre big screen, it' surreal)
- Depth (how a new menu open up on top of the other, is very different of the 2d screen)

Designing context specific Audio feedback plays a big role in immersion. It's very hard to click on the minimise and close button on the corner of the window. The UI is hypersensitive. There is always a fear of doing things unintended. When hovering, the new state brings up the full name of the game or the card. It's more consistent with the real world familiarity.
It's hard to operate the slider. To grab the knob in the slider bar. It's usually smaller than normal buttons. The switch button does not feel intuitive because it does not have compliance to real world resemblance. Users like the fact that the UI elements are not confined into a small window, rather its utilising the whole space around.

### Navigability

No / poor feedback on Status, Specially in immersive mode, No clear back buttons.

*"There's no back button, and I am confused how to go about in the application from page to the other"*

Because the UI elements are utilising spatial arrangement, it gives a far better sense of grouping. Which leads to easier and faster sense of navigating through the interface when exploring options from a long list they use sort, filter, etc. When they have to open a particular app, they just use the search field. However participants feel the easiest way is scrolling to the app position (users tend to remember the position of the app in the list / grid).
Scrolling is a bit frustrating in the tab mode and I have to control it with hand gestures. IGO cannot be a rectangular menu in the space, navigation would be cumbersome. It should be something quickly

accessible at the go, close to the body. Users would like as few buttons as possible, and they would not mind to go to the second click or the next.

**Usability perceptions**

For Clicking on multiple targets in a small span of time or interaction heavy configuration, setting things up (clicking, searching, typing, pausing, resizing), operation or use case requiring frequent/rapid inputs, interaction in the near field flat screens are preferred. For consuming content in the curved and far field screens are better Glyph based data feels more accessible in 2d screens in terms of legibility and readability.

*"Games with first perspective shooting has to give me visual access to my keyboard and mouse"*

**Interactions**

The vector of the leading from hands to the circle on the screen feels very non intuitive, conflicts with direction of the hands. Gestures were very limited, grab or Resize doesn't feel intuitive. Pre Decided angles, no control over rotating the interface.

After synthesising insights from the user study, a brief persona was created to have a specified direction for further design decisions.

**User Persona**

**Alex John | 30**

Software Developer

Has a VR headset and is enthusiastically looking for games to try out the full potential of the device.

**User goals**

1. Discover new and exciting VR game experiences and build a collection of top-rated games
2. Connect with other VR gamers and join multiplayer experiences
3. Share VR gaming experiences / snips / stream with friends and online communities

**Motivations**

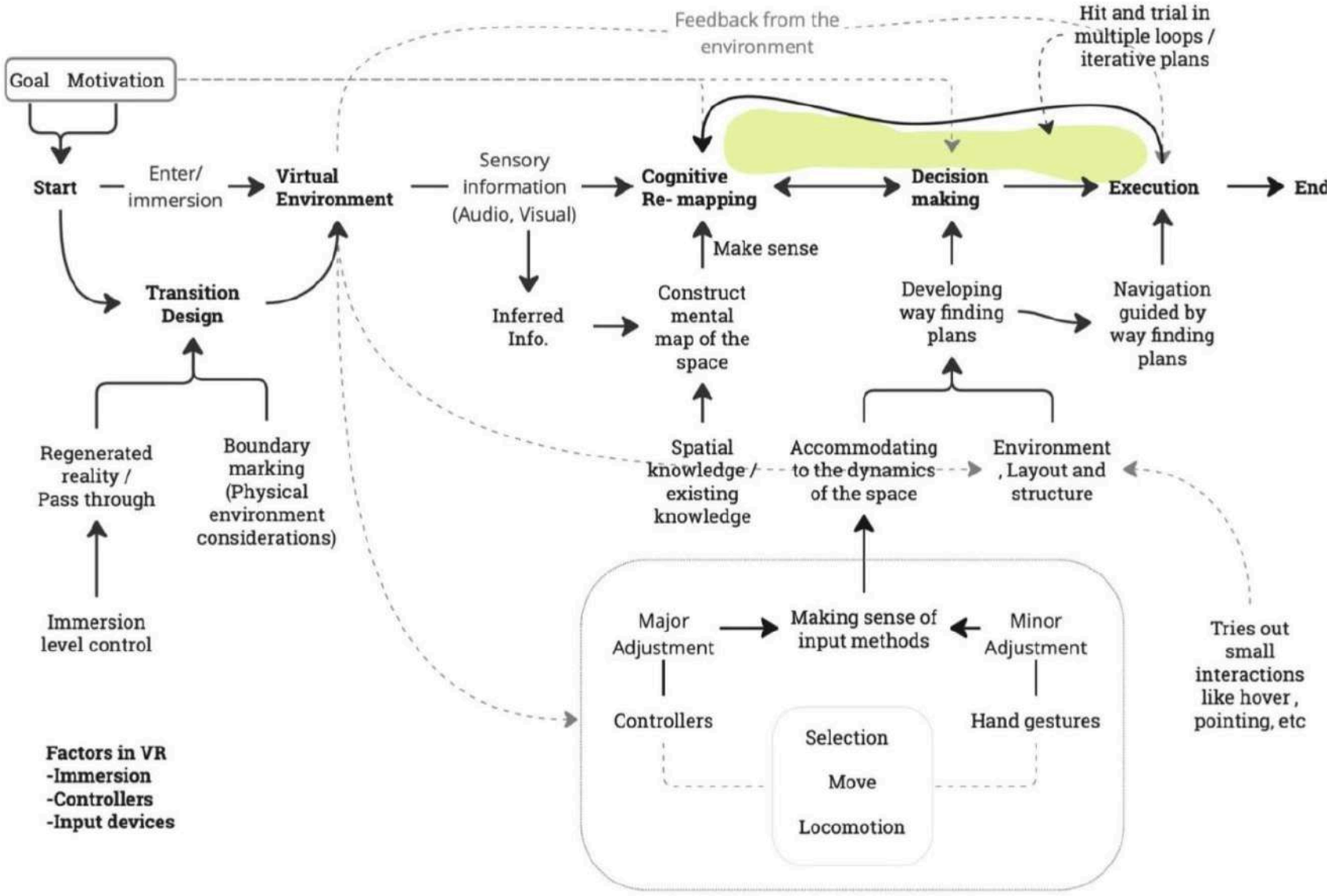
1. Passionate and thrilled by the immersive nature of VR games
2. Desire to escape reality and explore the virtual world
3. Curiosity to try out the latest VR technologies
4. Interest in pushing the boundaries of gaming
5. Intrigued by the possibilities of VR in game development

**Frustrations**

1. Limited options for VR games in the market
2. High prices for VR games
3. Incompatibility issues with VR headset and game
4. Lack of customization options in VR games

**Mental model of navigation in a VR environment**

Based on the interview data, a diagram of the user's mental model was created to visualise and understand users and their ways of navigation in our context.

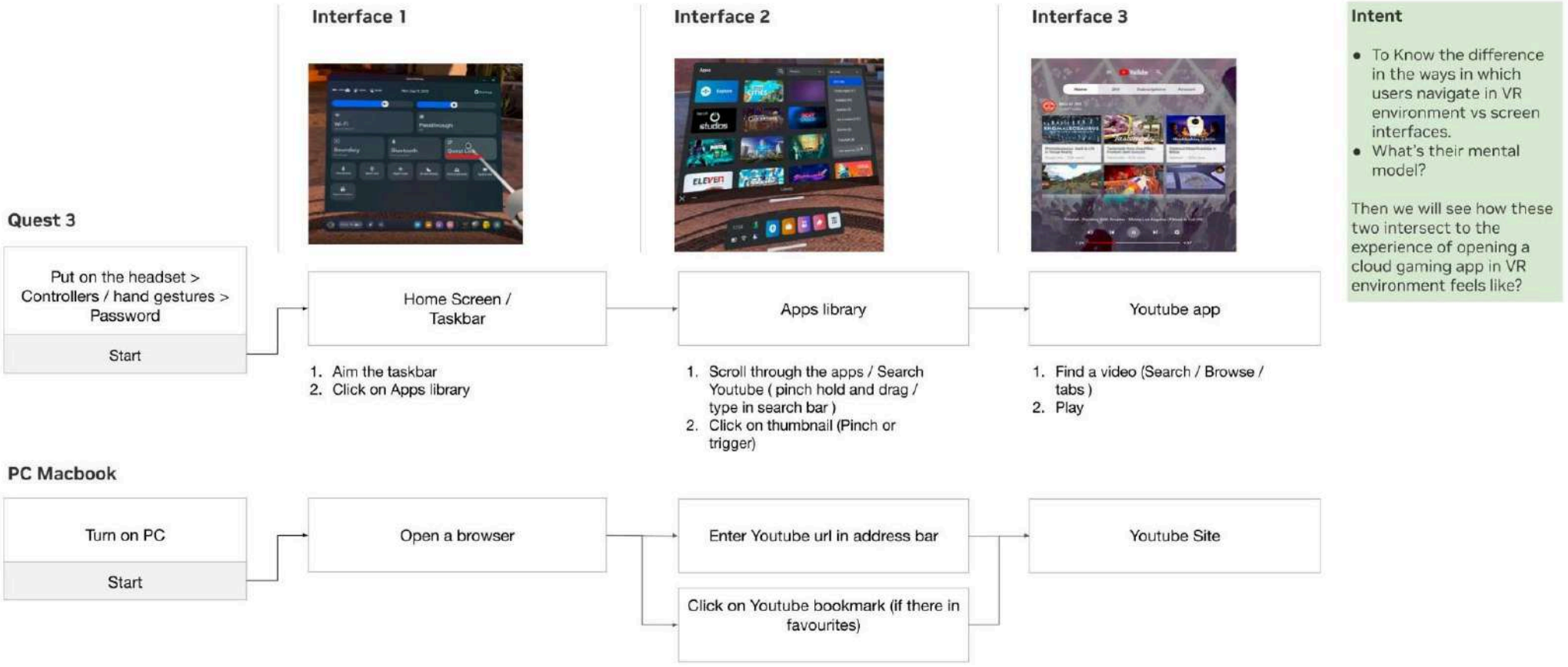


# 4. Design Development

**Flow comparison**

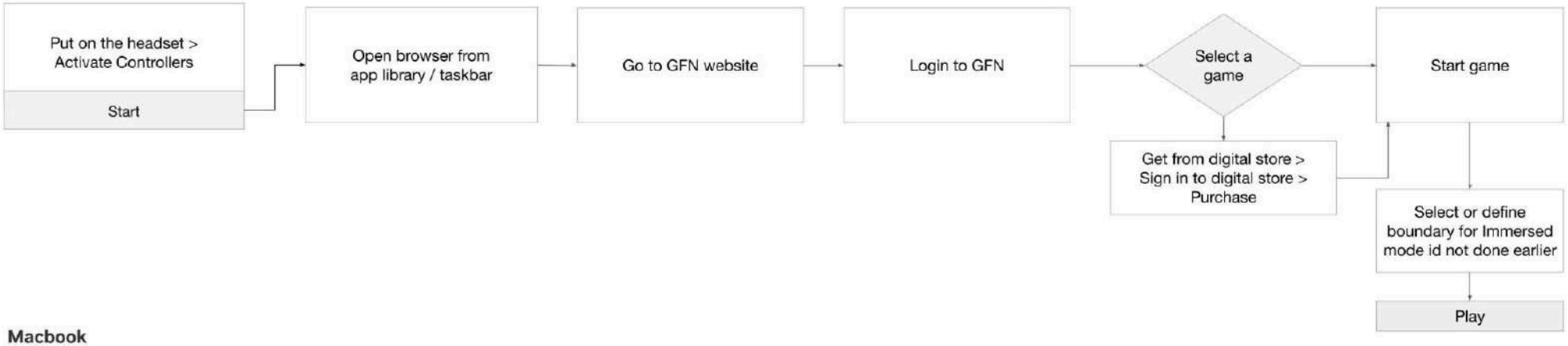
In the next step of the project, existing flows were taken up and studied in comparison to different modalities. For example, the flow for opening a game in VR vs that in a normal laptop, or opening a video in Youtube VR vs that in Macbook safari.

1. Flow for **Opening an app (Youtube) in :**

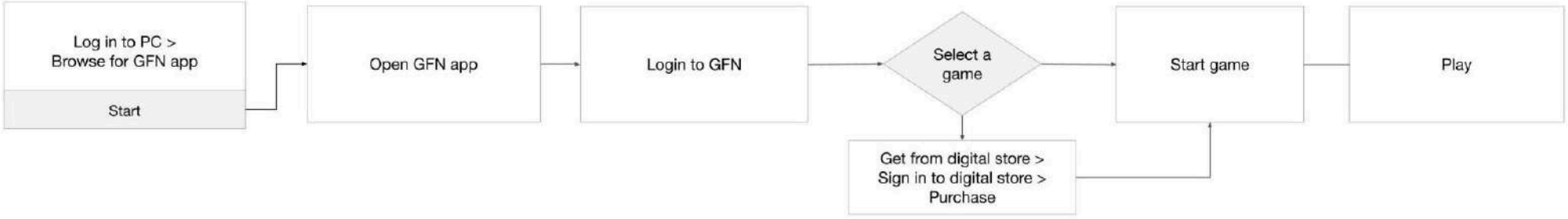


**2.** Flow for **opening a game in VR vs PC (in GFN cloud gaming)**

**Quest 3**

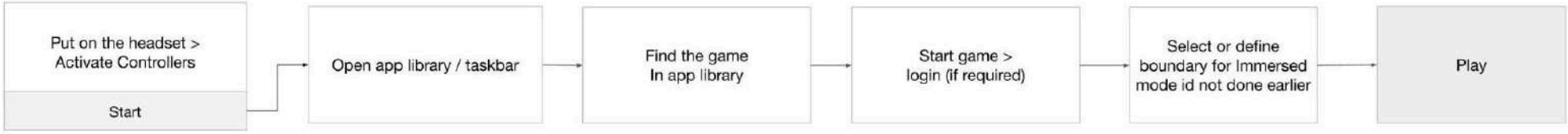



**Macbook**



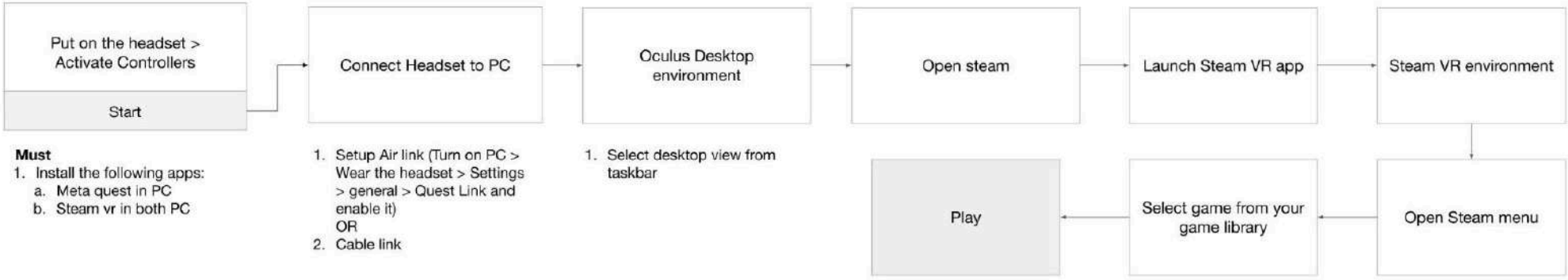
**3.** Flow for **opening an existing game in VR**

**Quest 3**




**3.** Flow for **opening an existing Steam VR game**

**Quest 3**



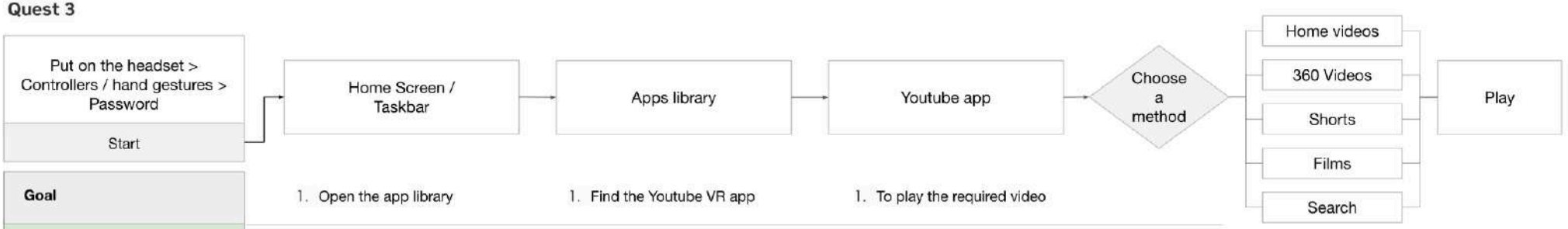

**Must**
1. Install the following apps:
   a. Meta quest in PC
   b. Steam vr in both PC

1. Setup Air link (Turn on PC > Wear the headset > Settings > general > Quest Link and enable it)
   OR
2. Cable link

1. Select desktop view from taskbar

1. Journey map for **Opening Youtube app and Playing a Video**

**Quest 3**




| | | | |
|---|---|---|---|
| **Goal** | 1. Open the app library | 1. Find the Youtube VR app | 1. To play the required video |
| **Action** | 1. Aims the taskbar<br>2. Clicks on Apps library | 1. Aims the screen app field<br>2. Scrolls to find the app or Uses the Search field | 1. Aims the screen<br>2. Browses for the video<br>3. Plays it in immersive mode |
| **Feels** | 1. "It's can be tricky to aim the small icon at the corner, specially when the screen is in a distant mode"<br>2. "I would prefer to keep the screen at reachable distance, so that I can interact with it directly like a touch screen" | 1. "I opened two apps by mistake, trying to scroll down, which was a bit frustrating"<br>2. "I would like some quick method to navigate to my app"<br>3. "Here also it's difficult to control when the screen is at the far point" | 1. "It's definitely very difficult to type in the search field, I would rather prefer some other ways to search, like voice search"<br>2. "I like how the interface elements are not confined within a border and uses the space around, giving an essence of surrounding me"<br>3. "Feels refreshing and lesser mental load than 2d screen"<br>4. Here also Pinching and selecting individual buttons is very difficult, It would be nicer if all the youtube controls can be done at my reachable distance" |
| **Takeaways** | Icons and buttons with bigger selection fields | Scrolling and swiping is best and most easiest when done in flat panels with touchscreen like interaction | When content is being consumed, it's preferred at a far distance, with a big screen, but video controls are a bit harder because clicking them with hand gesture is very tricky<br>Aim > Hover > Stabilize > Pinch (often multiple times) |

**Key flow for our design**

Deriving insights from the above study, a key user flow was created for our cloud gaming platform. It was majorly categorised into 3 major categories, which are :

1. **Browsing**

   This is the beginning of the user journey where the user browses through the whole inventory of all games available on the platform or if they are an existing user they will browse for their owned game. This will include using sort and filter options, search field, several microinteractions, etc.

2. **Game Inventory**

   This is the setup just before launching a game or purchasing the game where the user will have a quick look or an elaborated read or research in order to decide whether to play or purchase the game or not.

3. **Within Game**

   These are the interface elements which appear inside the game, during gameplay. Which provides in-game controls like taking a screenshot, recording the screen, etc.


**User stories**

Under each broad flow category user stories were created to put the goals and objectives into a structure.

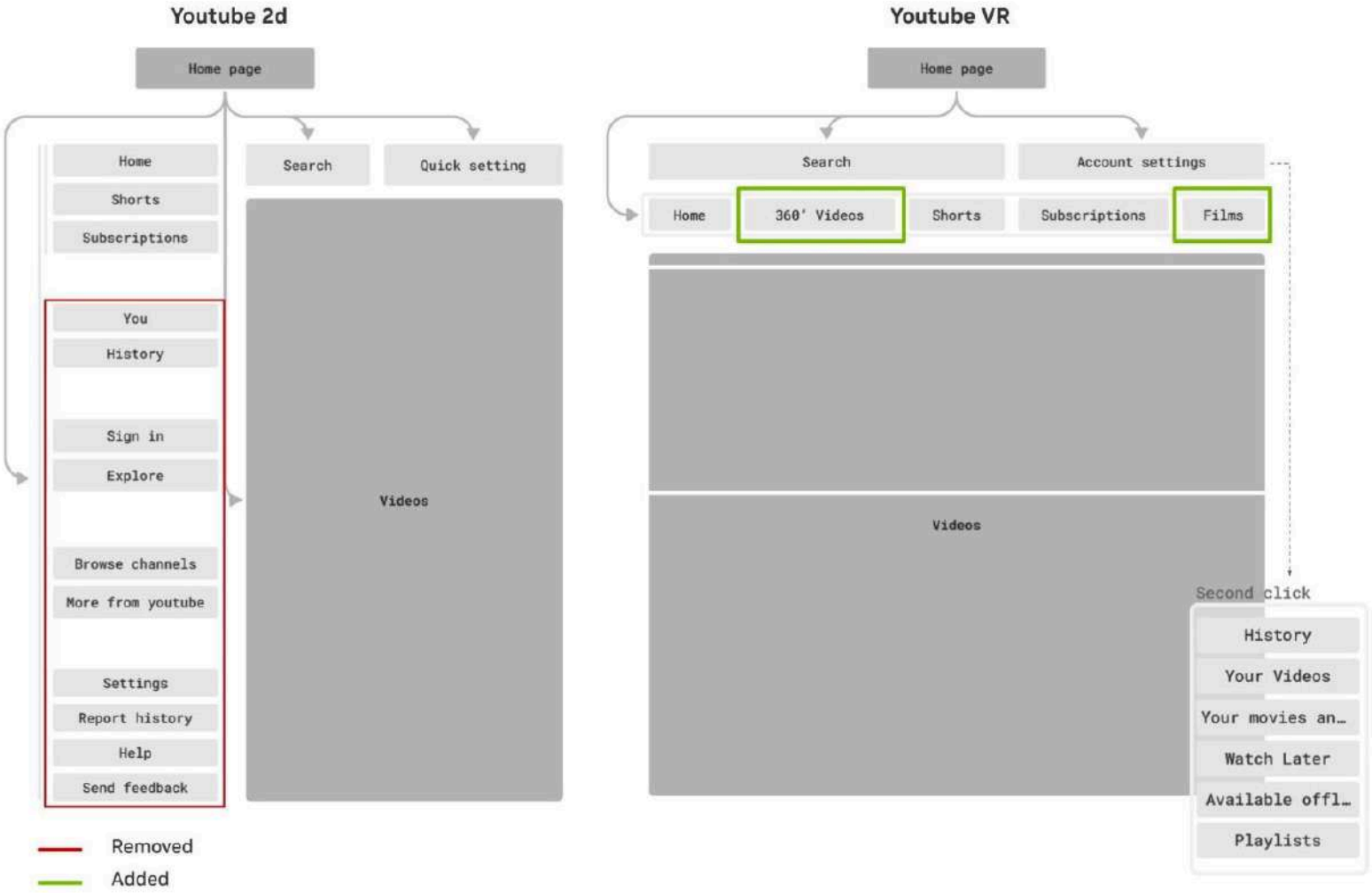
**Link to full diagram :**
*https://www.figma.com/design/F75toLFilU5epPNuBPfG6G/Rajdeep?node-id=367-2258&t=F2Gh7CoZtrbgPr5h-4*

User were written in the form of :
**As a _____, I want _____, So that _____ .**

To give an example, one user story was :
**As an** enthusiastic VR gamer, **I want** a method to login where I don't have to type / type every less. **So that** I can skip the hassle and frustration of typing using an on-screen keyboard in VR.

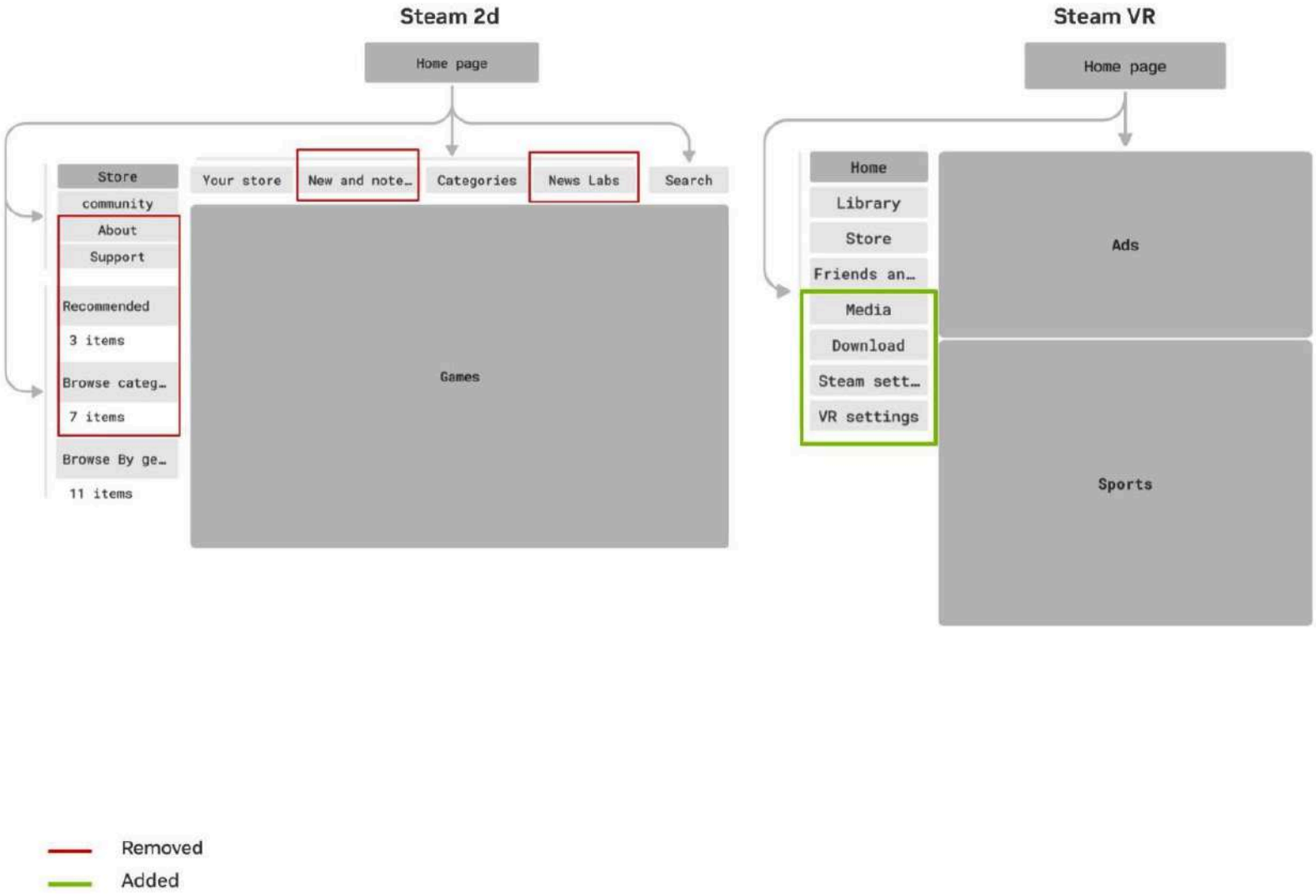
**Information architecture**

Similar to flows, information architecture of Steam and Youtube was studied in terms of how they were translated / redesigned from 2d screens to VR interface.




**General OBSERVATIONS**

| | Youtube 2D | Youtube VR |
|---|---|---|
| Organization | 2D , static | Spatial, 3D, Dynamic, Responds to environment |
| Navigation | Primarily list view, browsing, scrolling | Users explore content by physically turning their heads or using hand controllers to point and select elements |
| Information density | High, due to higher affordable precision in control | Minimalistic approach, prioritization of most important elements |
| Personalization | Lot of options available (theme, keyboard shortcuts, etc) | Not available in youtube VR |



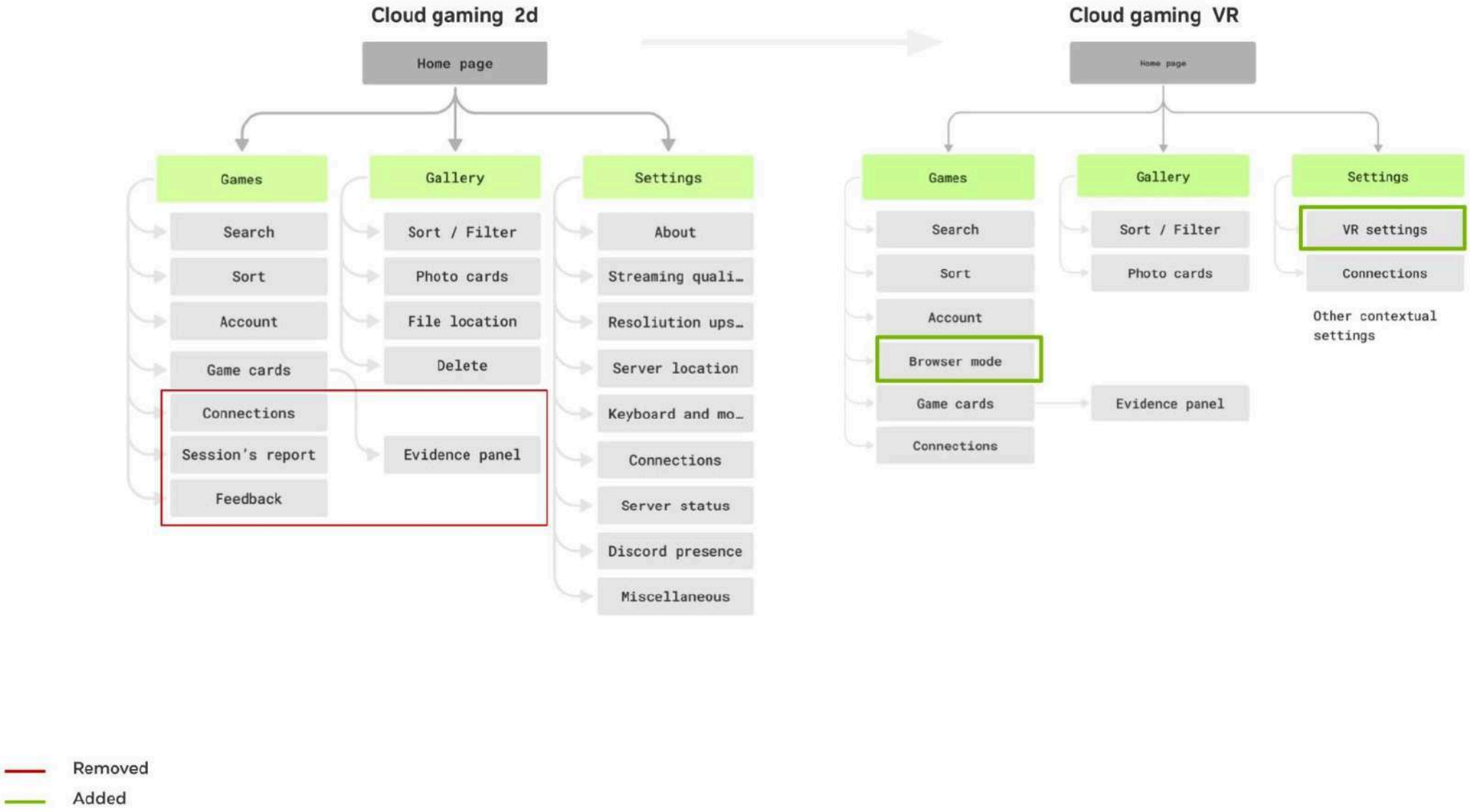

**General Insights**

1. **Utilitarian approach**:
   Information is only presented in a high priority order, primary page has a very limited no. of options. Other options are either omitted or moved to second level in IA hierarchy.

2. Axillary agendas like marketing, increasing engagement, etc are set aside.

3. Contextual options like VR settings are added in the VR mode.

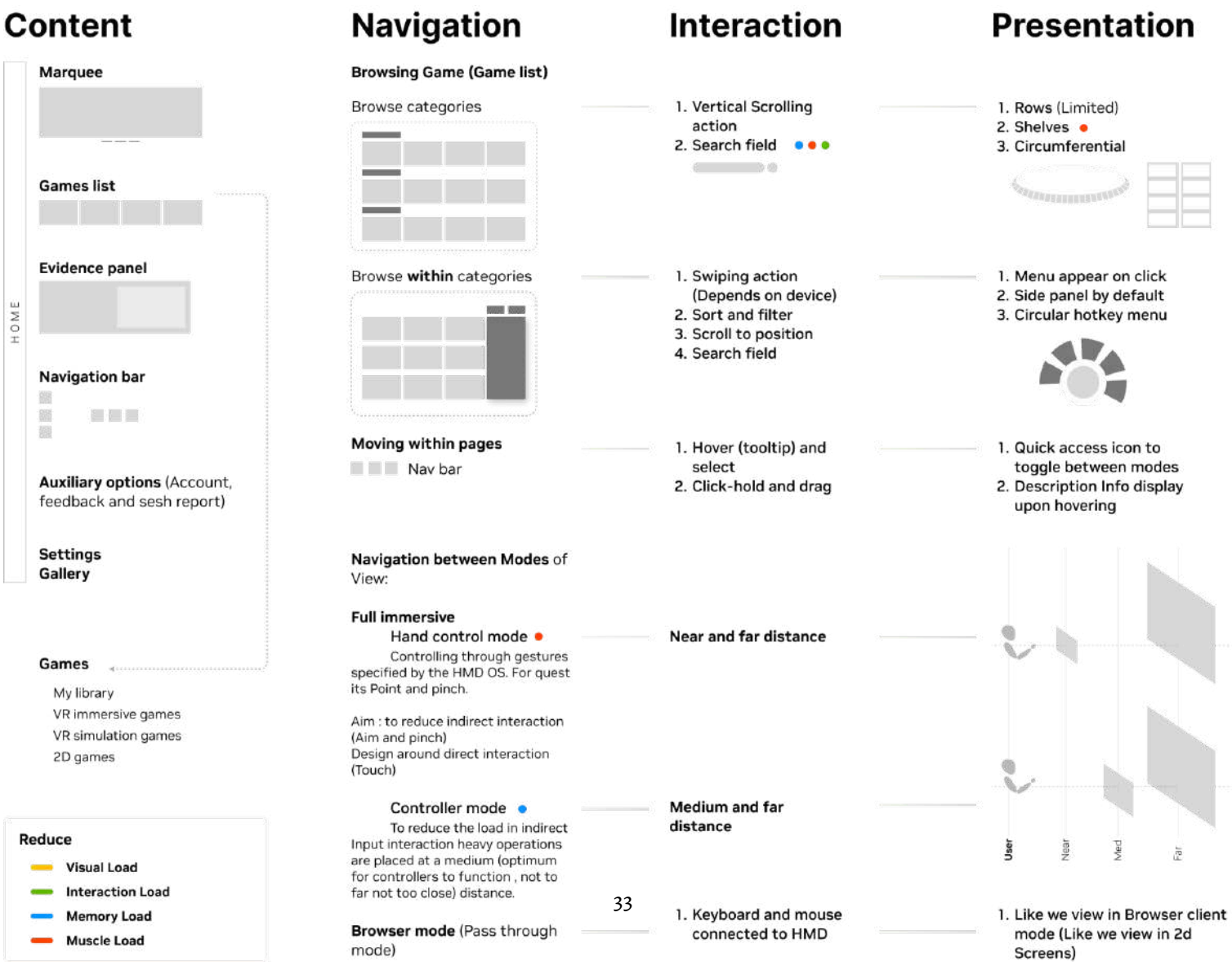
Based on the study of existing approaches, an example of a rough information architecture for our platform was conceptualised.



## 5. Ideation

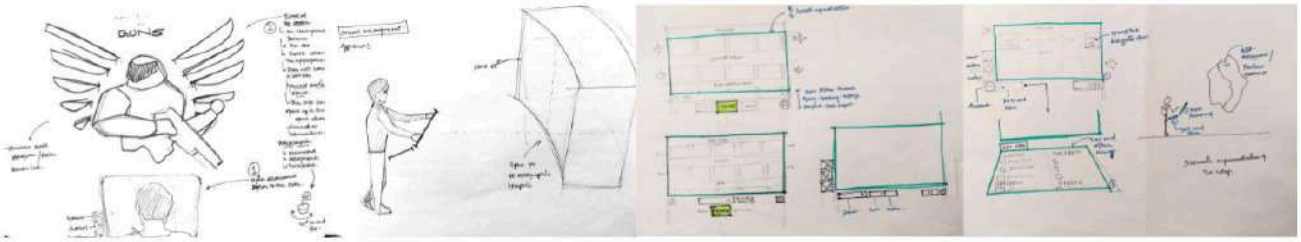
### Framework for ideation

A framework was created consisting of major categories which basically guided me in terms of what all to think about when thinking of redesigning the interface from scratch.

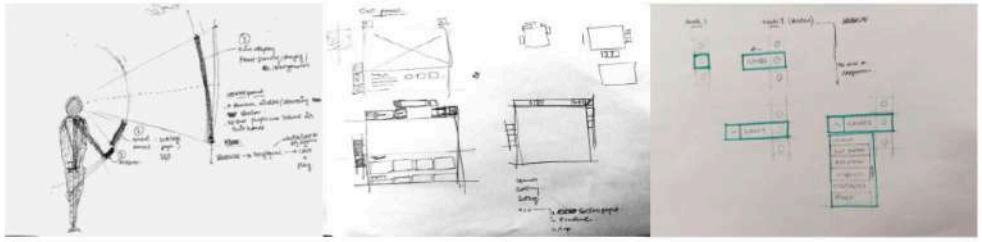


## Initial Ideation sketches

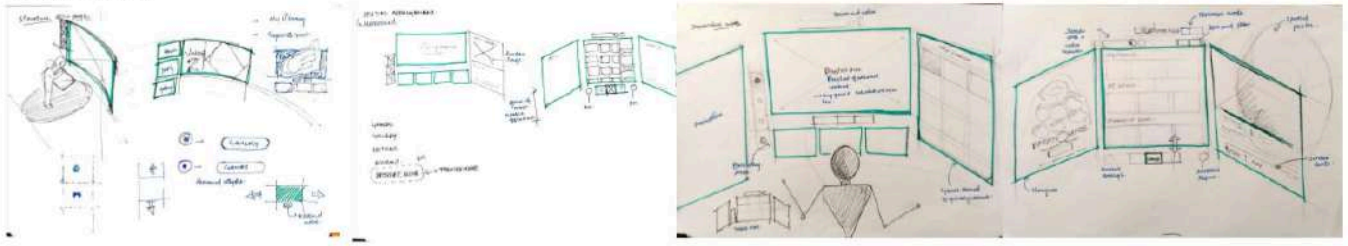
DIRECTION 1



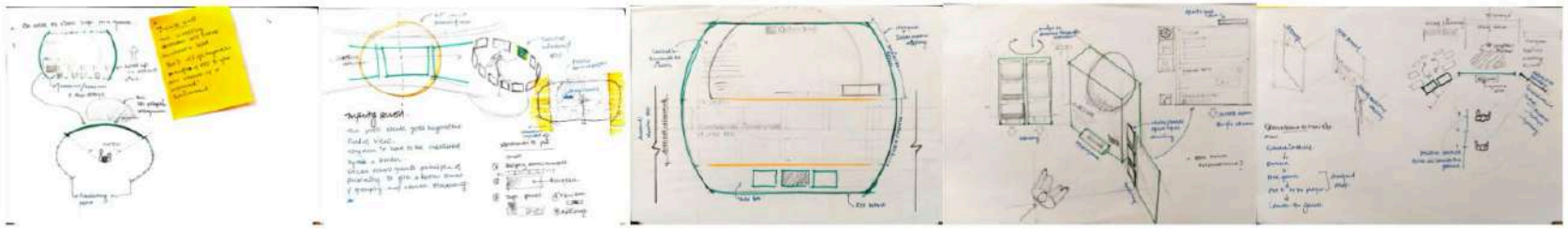
DIRECTION 2



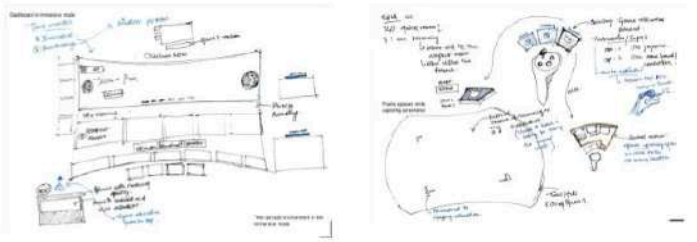
DIRECTION 3



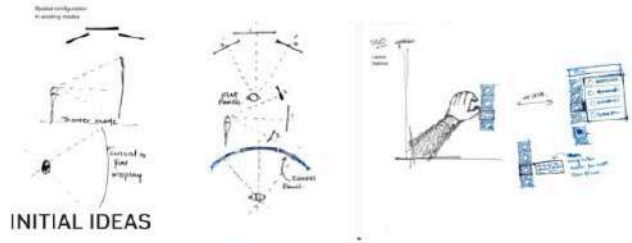
DIRECTION 4

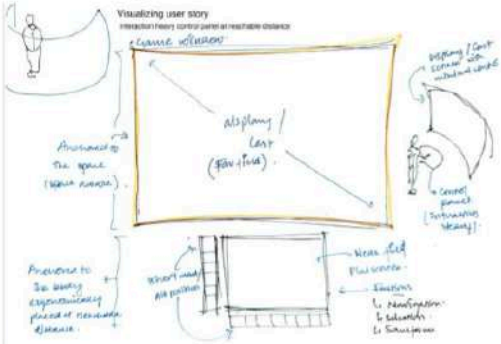


IN GAME OVERLAY



INITIAL IDEAS



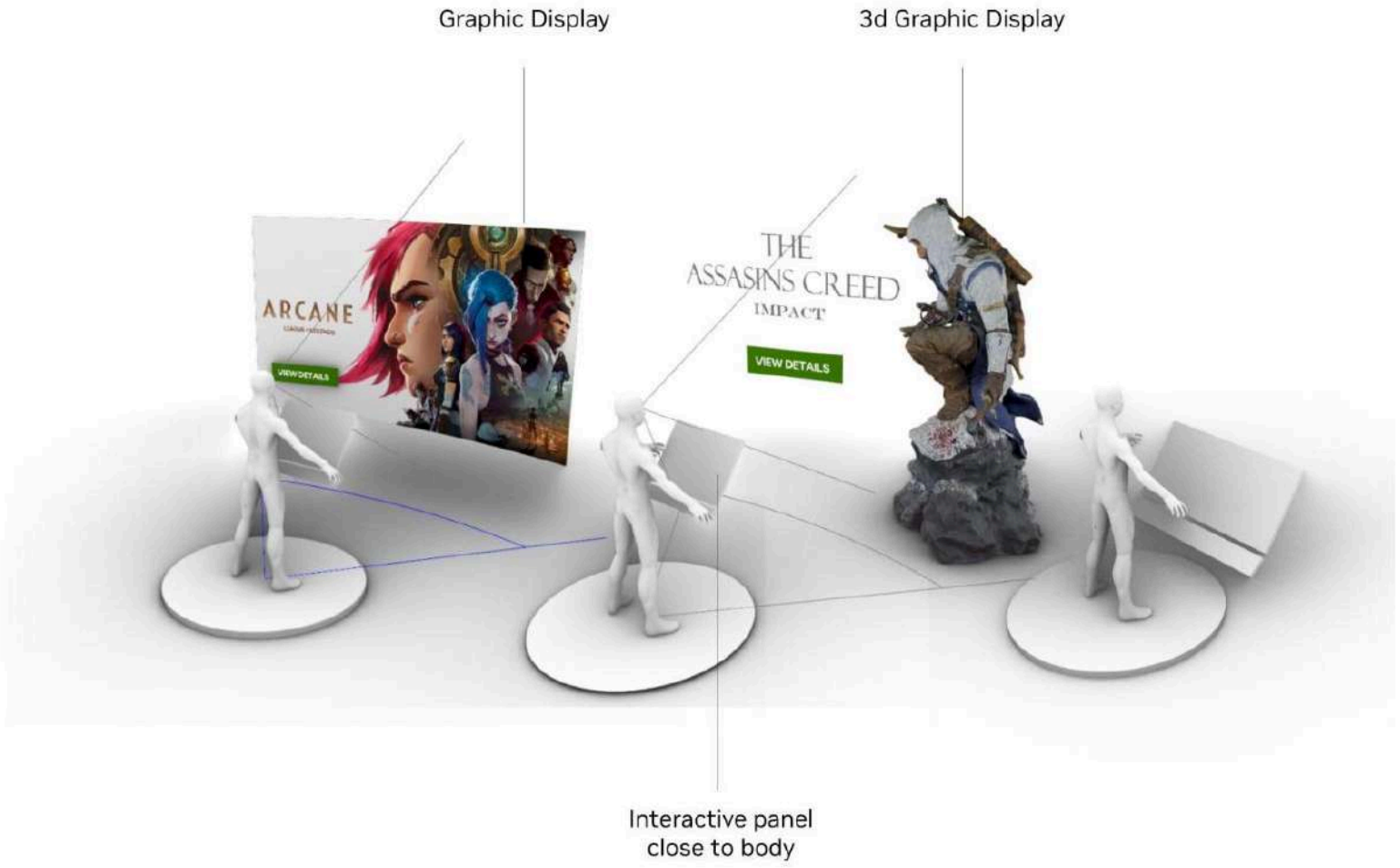


These ideas were discussed and 7 ideas were visualised using 3d tools.

1 **Graphic vs Interaction**

-Configure and launch

-Focus on familiarity and usability



2 **Humanoid scale UI**

-Everything is at the far distance

-Matches to human perception of real world space

3 **‘Surround’ interface**

-Infinite scroll

-In the real world objects are not bound to **FOV**

4 **Control panel**

Controls happen at an interface close
to body space
And effect can be seen in the space

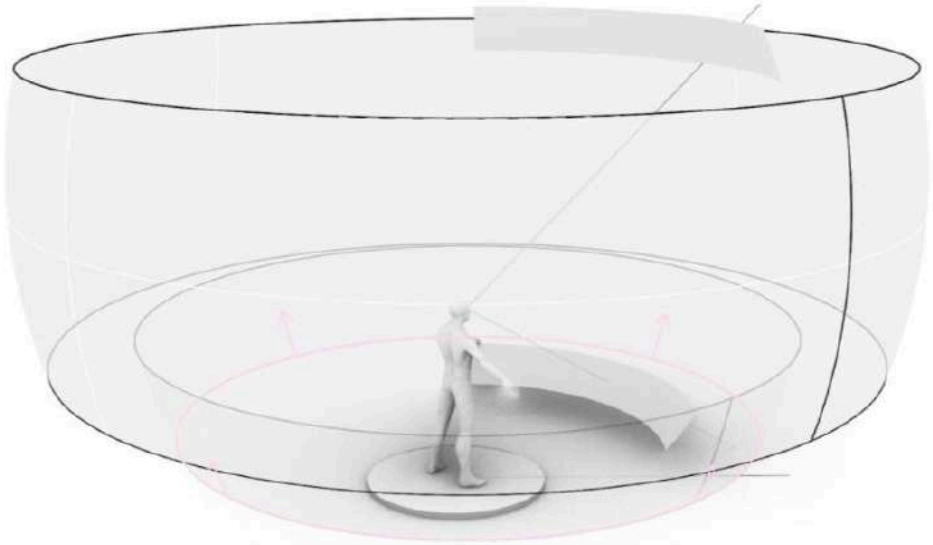
**5** **Classic essence of gaming**

-draws inspiration from the time of 'Game on shelves'

6 **Arena**

-Grandness of the space

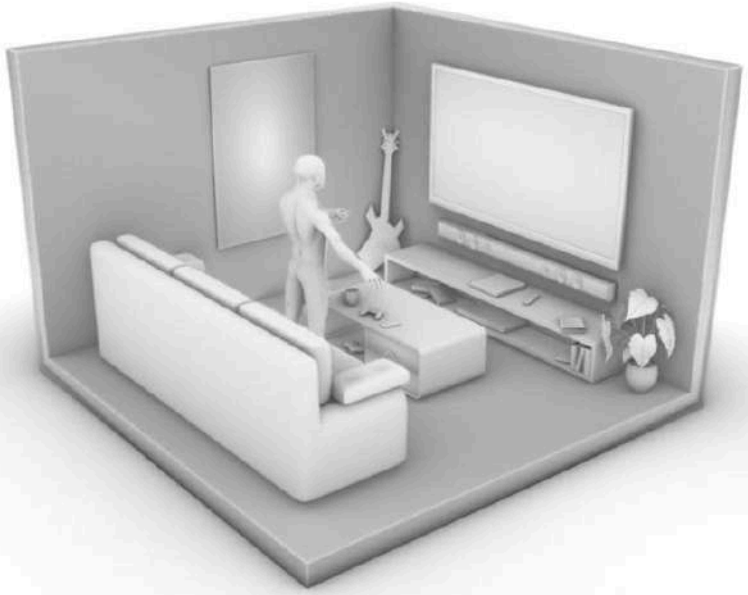
-User has the added control to configure their screen positions



7 **Gaming room**

-Go to the game and play

-An environment , appears when playing a 2d game with controllers



## Evaluation of Ideas

### Weighted design Matrix

This is a heuristic evaluation of the ideas based on perceived value of each factor. These parameters are assigned weightage according to secondary user research on usability within the VR environment. All concepts are rated on a scale of 1-10 and then summed up according to their weightage.

- **Visual load**
  Visuals still play a crucial role in user experience and information clarity. Interfaces should present information clearly and avoid overwhelming the user with visual clutter.

- **Interaction load**
  Priority remains on intuitive and efficient VR interaction for seamless navigation and control within the GeForce Now environment. Interactions that leverage the strengths of VR controllers and minimise the need for complex gestures or button combinations.

- **Memory Load**
  Memory load here refers to minimising cognitive strain.
  A complex interface with overwhelming information or confusing workflows can overload a user's working memory, leading to frustration and difficulty completing tasks. The focus is on clear structures and minimising the need for users to remember complex steps to achieve tasks.

- **Muscle Load**
  Similar to the previous weight, muscle load from controller interaction is a minor factor compared to user experience and efficiency. Prioritise interaction methods that are comfortable and minimise fatigue during extended use.

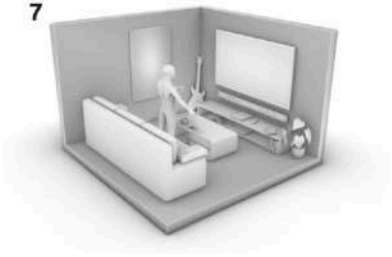
- **Consistency with existing UI**
  Maintaining some familiarity with the existing UI can ease user transition, but prioritise a VR-centric design that leverages the strengths of the platform.

| IDEAS CONCEPTS | VISUAL LOAD<br>20 % | INTERACTION LOAD<br>25 % | MEMORY LOAD<br>15 % | MUSCLE LOAD<br>5 % | CONSISTENCY WITH EXISTING UI<br>20 % | FEASIBILITY OF IMPLEMENTATION<br>15 % | TOTAL<br>100 % |
|---|---|---|---|---|---|---|---|
| 1 Jarvis<br>-Configure and launch<br>-Focus on familiarity and usability<br>  | 5<br>Complex Visuals concentrated within a small area<br>The space used for graphics display | 5<br>Navigation is easy due to better placement of the interface | 6<br>Low memory load because of high consistency to existing UI | 7<br>-a- | 7<br>-a- | 6<br>-a- | 5.8 |

Not to simply replicate the 2D UI; adapt it for a VR environment while maintaining core functionalities and user expectations.

- **Feasibility of implementation**
  Rapid prototyping is valuable, but user experience and long-term feasibility remain key during evaluation.
  Considering the limitations of the Quest 3 hardware and software while prototyping, but not to compromise core functionalities for ease of development.

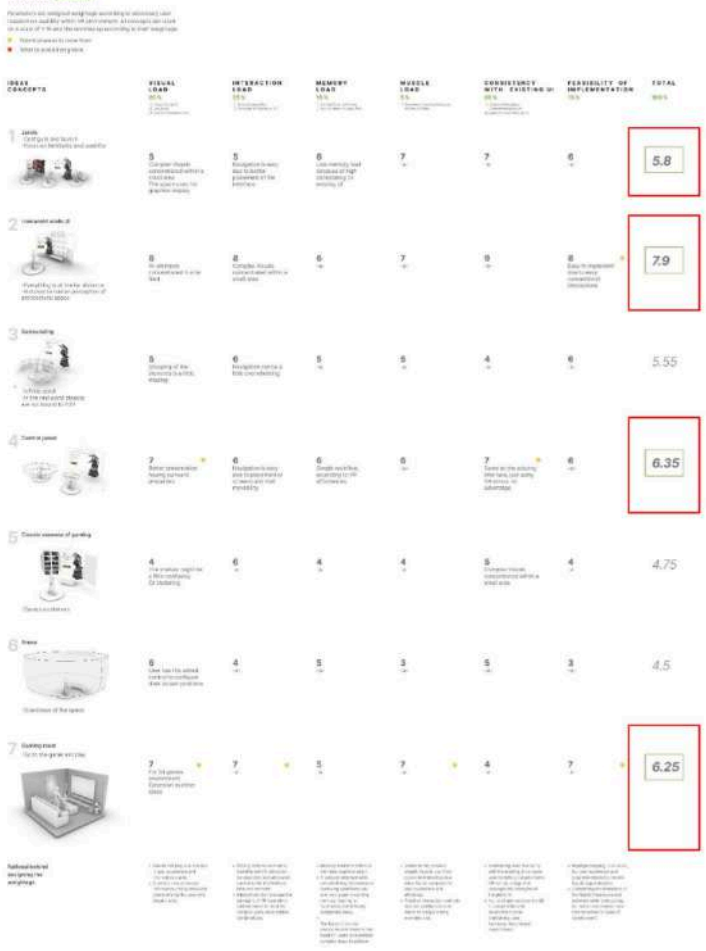



**Shortlisting ideas to take forward**

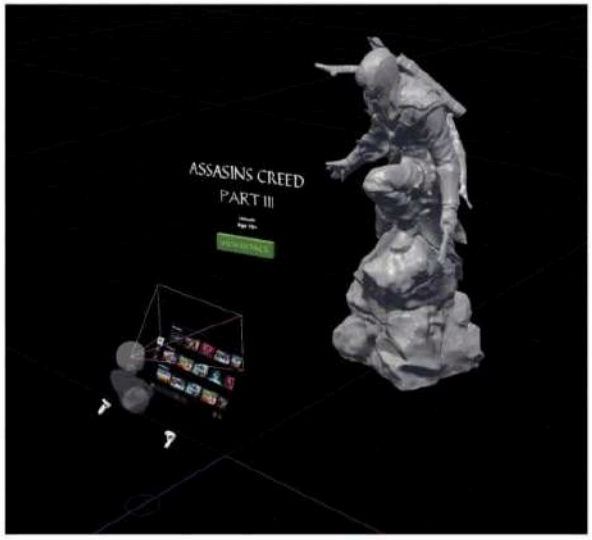
Based on the aggregate scoring of the ideas against six different parameters, 4 ideas with highest scores were shortlisted for further potential development. This was done alongside discussion with stakeholders about feasibility of implementation.

Not all of these were standalone independent concepts, rather could be useful when combined with others. For example the last idea (7th idea) was conceptualised for the gaming environment , which can be combined with any of the other ideas.



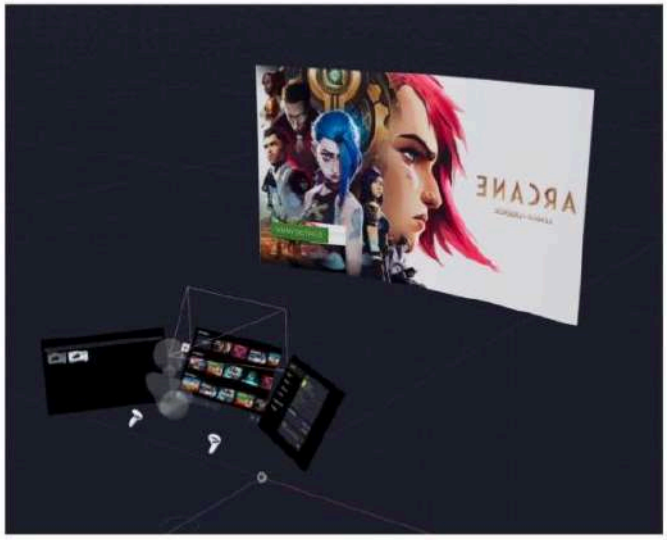
**Prototype development**

A total of 6 prototypes were created quickly to check their initial feasibility. These were created specially to see how they appear in the VR context. A software called Bezi was used to view the interface elements in the immersive mode. Below we have denoted a snip of each prototype followed by a brief write-up stating why it worked out or not.



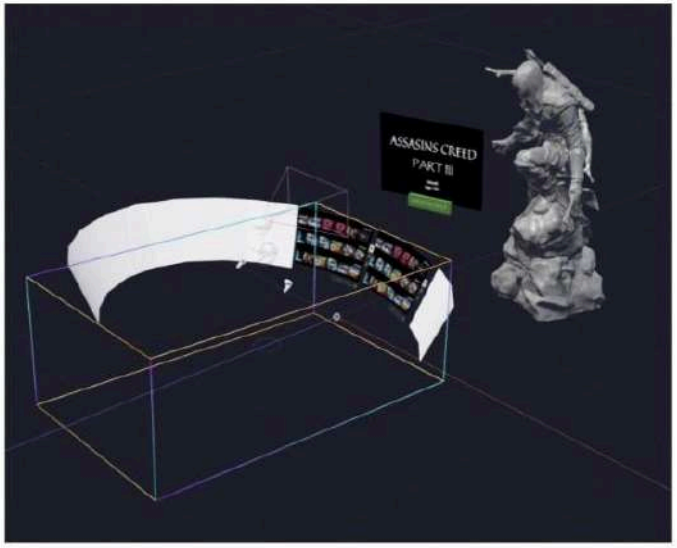

**Idea 1 : Graphic vs interaction**

In Spite of having the whole space available for the interface, why to crumple everything into a small space?




**Idea 1 : Extension**

Too near to the user, feels overwhelming at times due to imbalance distribution of density

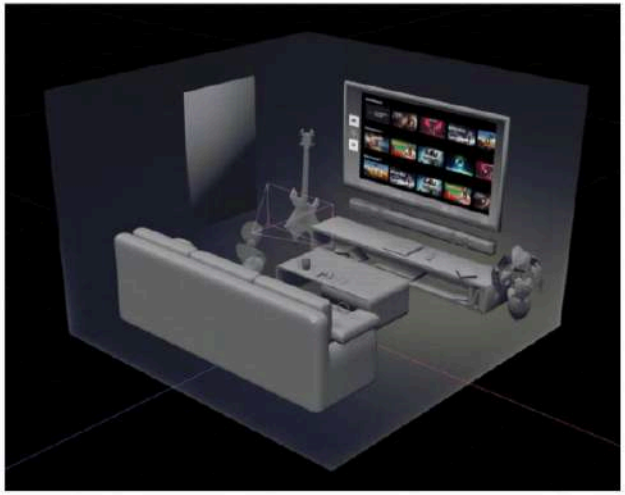



**Idea 3 : Control panel**

Feasibility limitation : Mapping UI elements on a perspective plane makes it difficult to adjust skew

After deliberation on each concept direction, the Humanoid scale idea was chosen, due to several factors one being that it had the most consistency with the existing interface, which means learnability was a priority for the users above everything.

Humanoid scale was the concept which leveraged the affordances of the VR to the maximum extent as it brought the scale of interface to the human scale using depth, layering and parallax.



**4 . Personalised environment**
When playing 2d games, Can be explored as a future scope

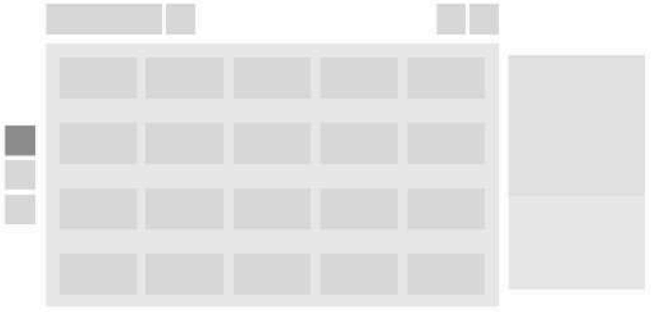

**5 . Humanoid scale**
Promotion area vs Browsing are vs Info. panel, too inconsistent with existing UI, Issues around learning curve


**5a . Humanoid scale (Version 2)**
Consolidation, more consistent with existing UI, Layering for hierarchy

**Skeletal structure exploration**

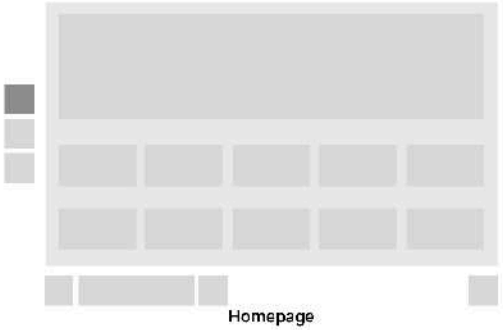
Based on our information architecture I started with basic exploration of the skeletal structure of the home page and some one click down pages.
Experimentation with the border treatment, how controls like navigation bar, search bar placement, whether to have a consolidated boundary or not.
Low fidelity wireframes were used to explore such factors.

Homepage

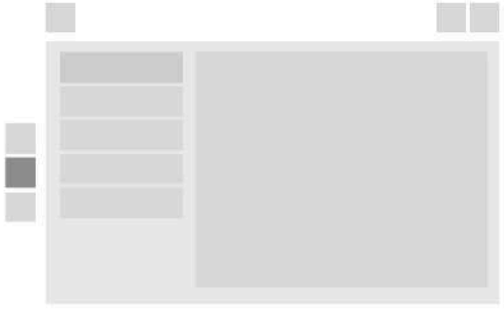


Browsing games
Sort / Filter

Evidence panel/ page



Homepage



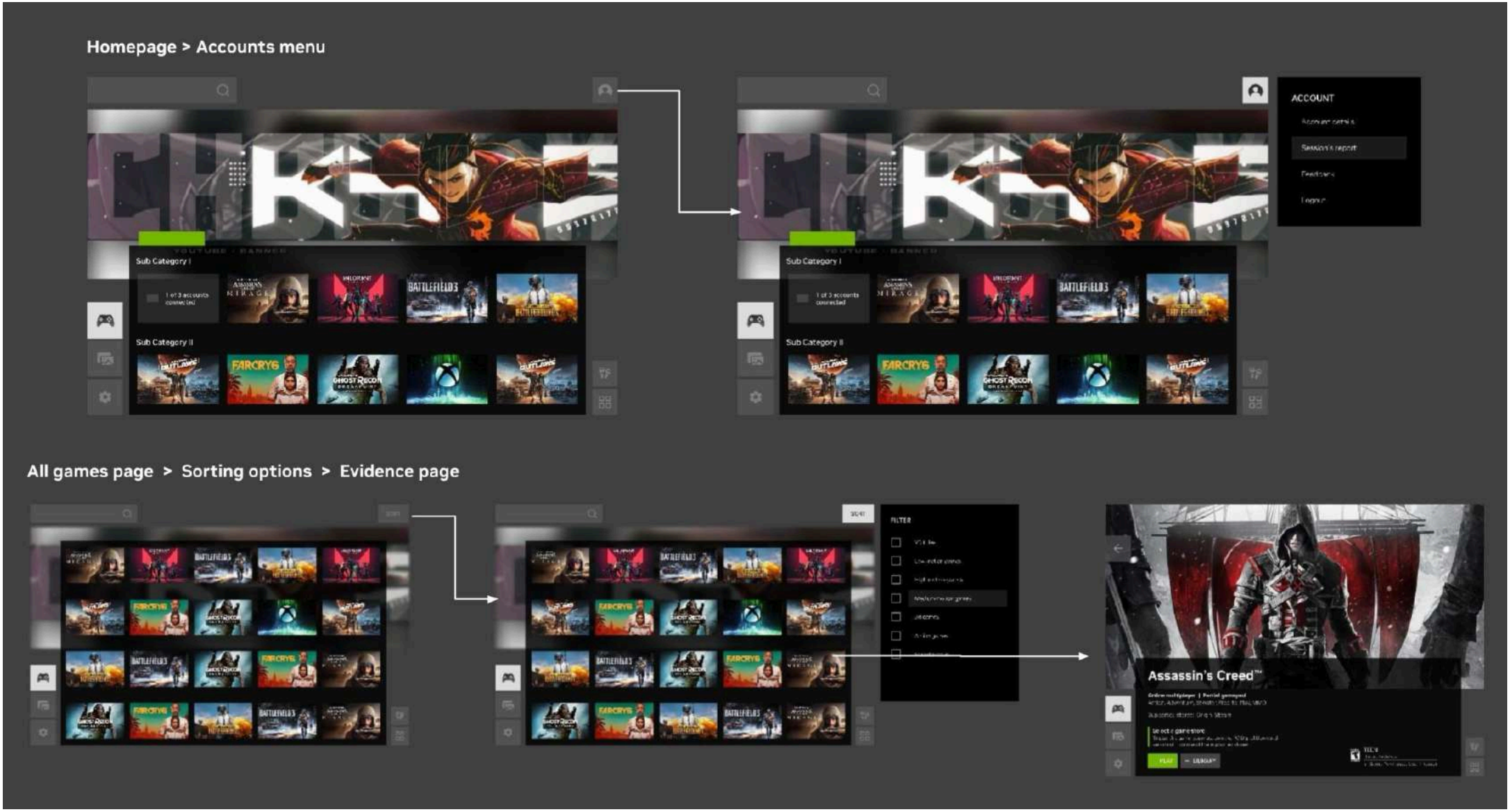
Settings

Gallery (viewing a photo)

## 6. Prototype development

### Prototype iteration 1

After layout explorations, one direction was chosen and prototyped in the VR environment. And conducted a quick pilot to get initial feedback on the first iteration.

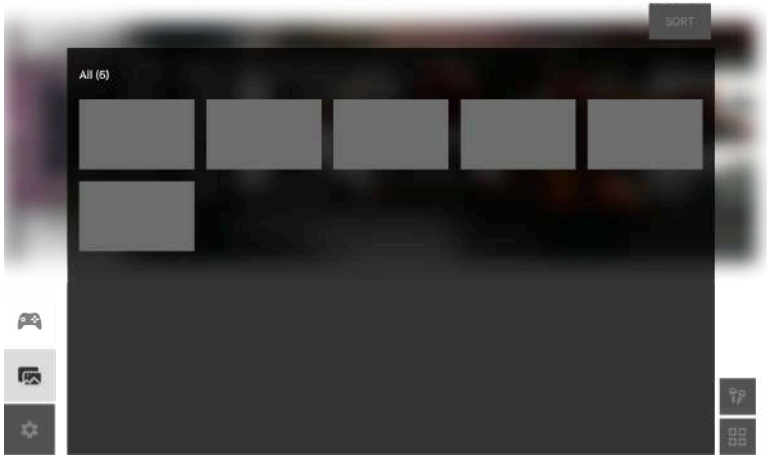



### Pilot study insights

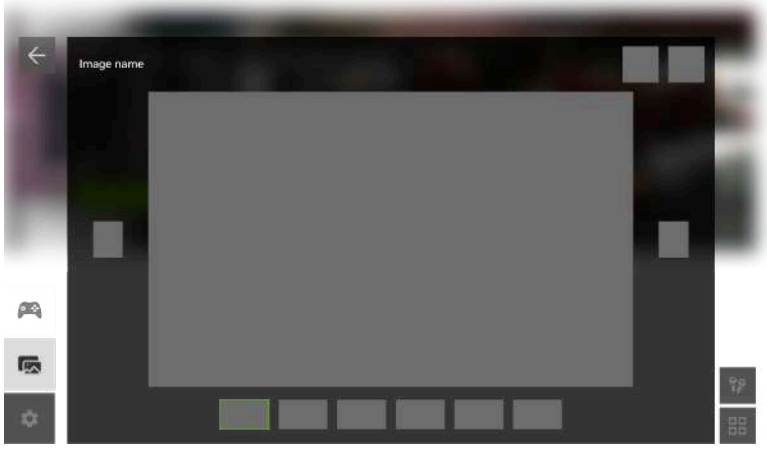
#### Onboarding

The transition felt like a shock, from pass through mode of quest UI to the fully black immersive mode of the Geforce now application.

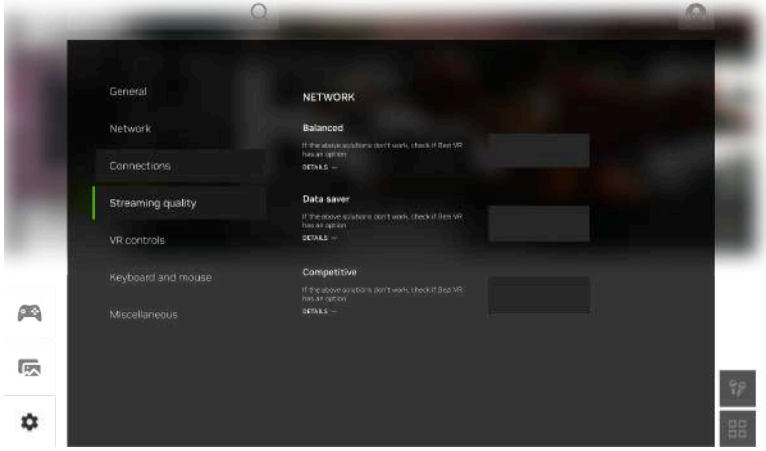
*"As a gamer I want my browsing experience to be very light, (maybe a passthrough), when I launch a game this fully focused and immersive mode is good"*




The gallery page shows saved screenshots and videos.




This is how we see a screenshot in a full view.




The settings page, contextualised (different sections condensed into side menu).

**Placement and Scale**

The screen is placed a bit far, although selection and navigation feels quite easy. Although users felt checkboxes are hard to aim and select in the filter menu.

*"The experience is nice but I think it's needs some optimisation in terms of distance and UI button sizes"*

**Background layering**

The marquee feels too intrusive, because it seems too rigid (as it is still present there in the background while browsing all games pages).

*"Since it is promoted content I would like it to have limited visibility/ presence. I would like to close it like we do for ads in a website"*

**Information mapping**

Placement of the account icon near the search icon is a little confusing, because they do not really have functional association. The Sort button in the bottom opens up a side panel with a list menu, is confusing and difficult to associate.

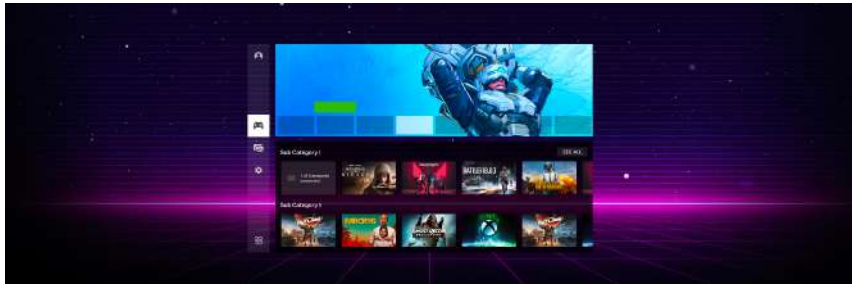
**Layout**

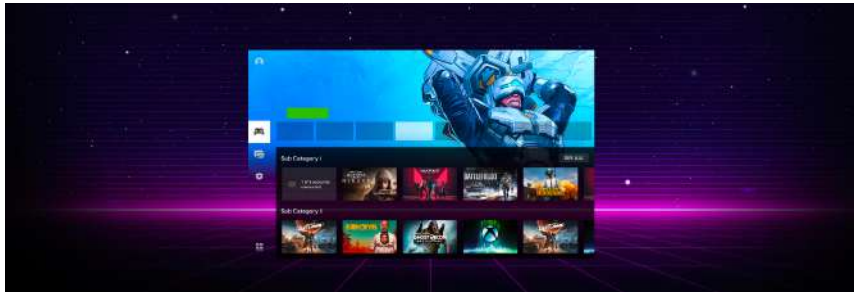
Users felt that the interface felt a little disjointed and needed a little more consolidation, because they had seen a lot of unfamiliar elements as compared to what they encounter in their day to day life. Hence familiarity to existing systems was missing.

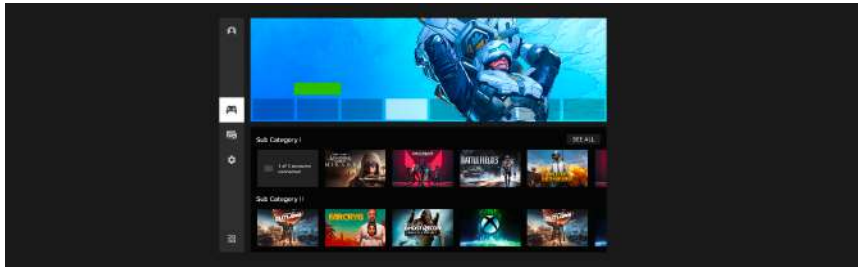
**Background explorations**

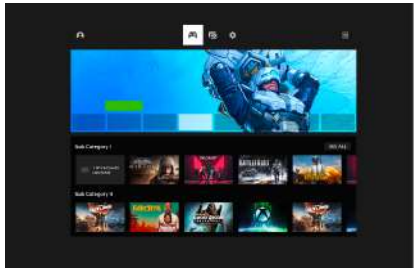
After the insights from the pilot study, I went on and looked at how we can place the interface in an environment. How can we define the environment without taking away the essence of the platform identity.

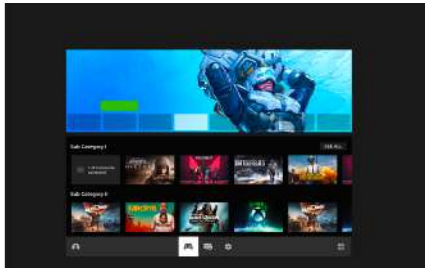
When we say background it means enhancing the spatial perception of how the interface is placed inside the immersive environment. How prominent should the environment be, or should there be any environment at all? Different iterations were tried with varying opacity, depth in UI elements, and background image intensity.







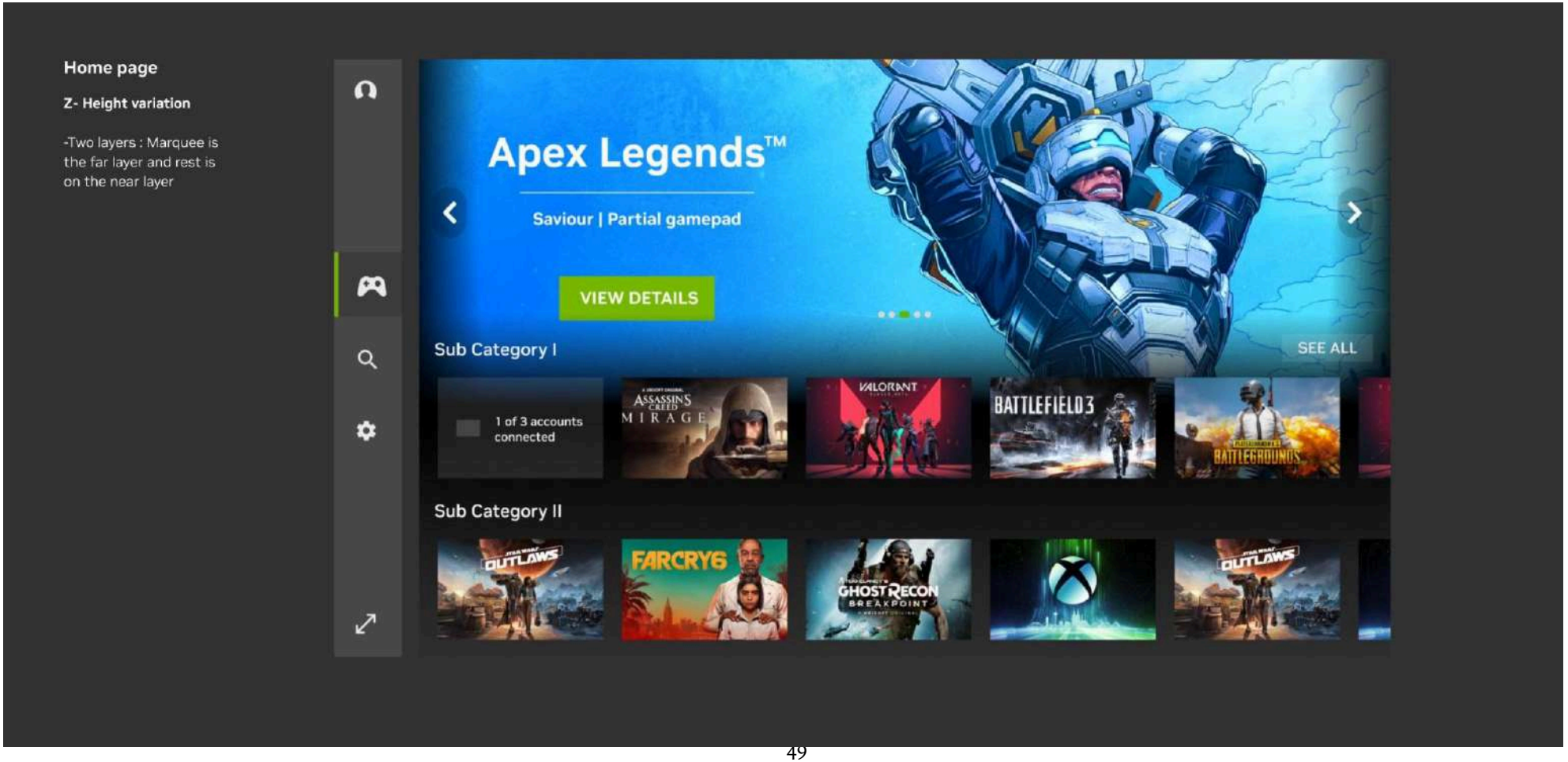


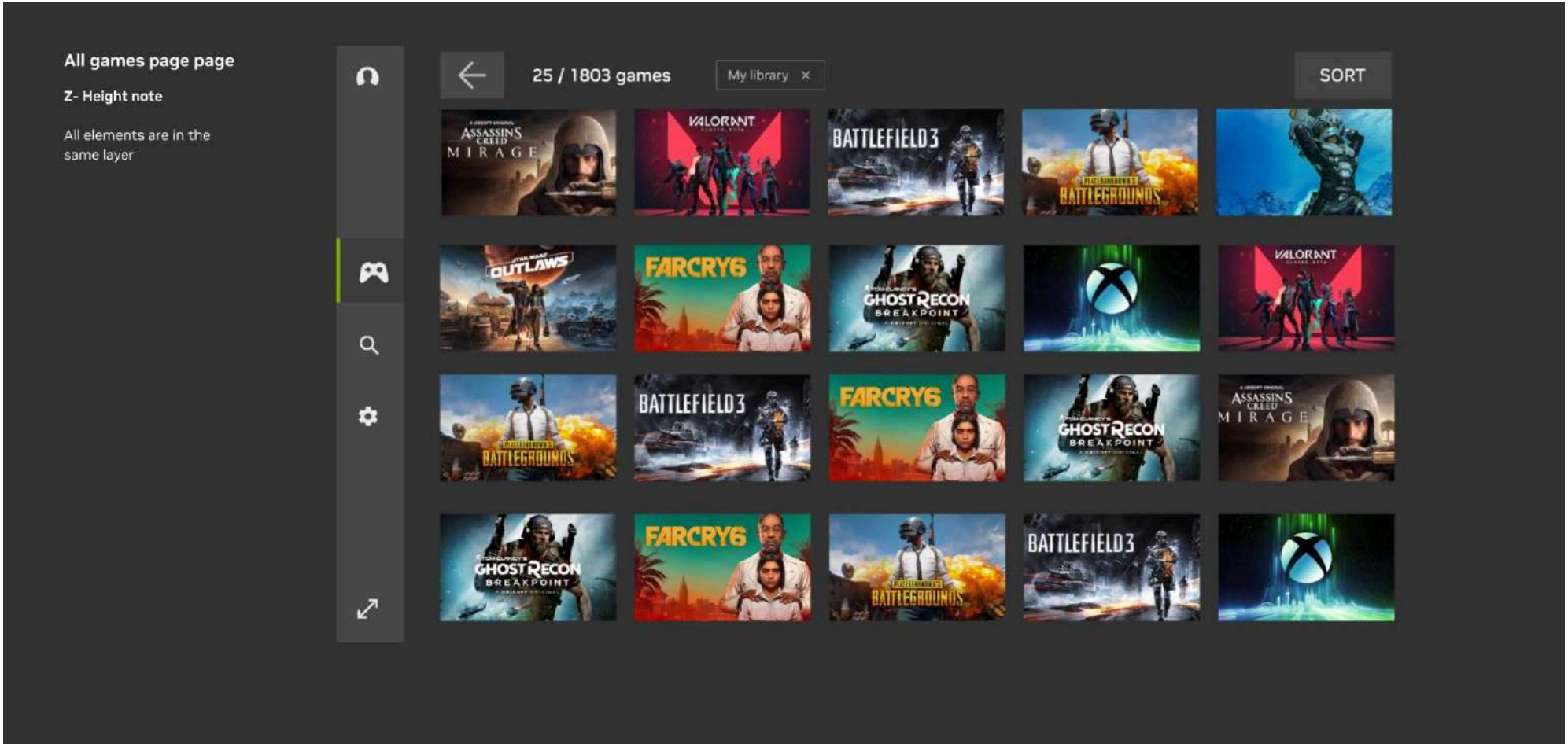


## 7. Final prototype screens

For the final iteration a prototype was made which focused on a very basic flow, which is finding an already purchased game and launching it. When  inside the game screen, the user would explore the in-game overlay, statistics menu and pop-up that led to transitions.

***Video prototype link :***
*https://drive.google.com/file/d/1obfJlmd7tdbPYnaXFPvzaiJTqOFDNk3H/view?usp=sharing*



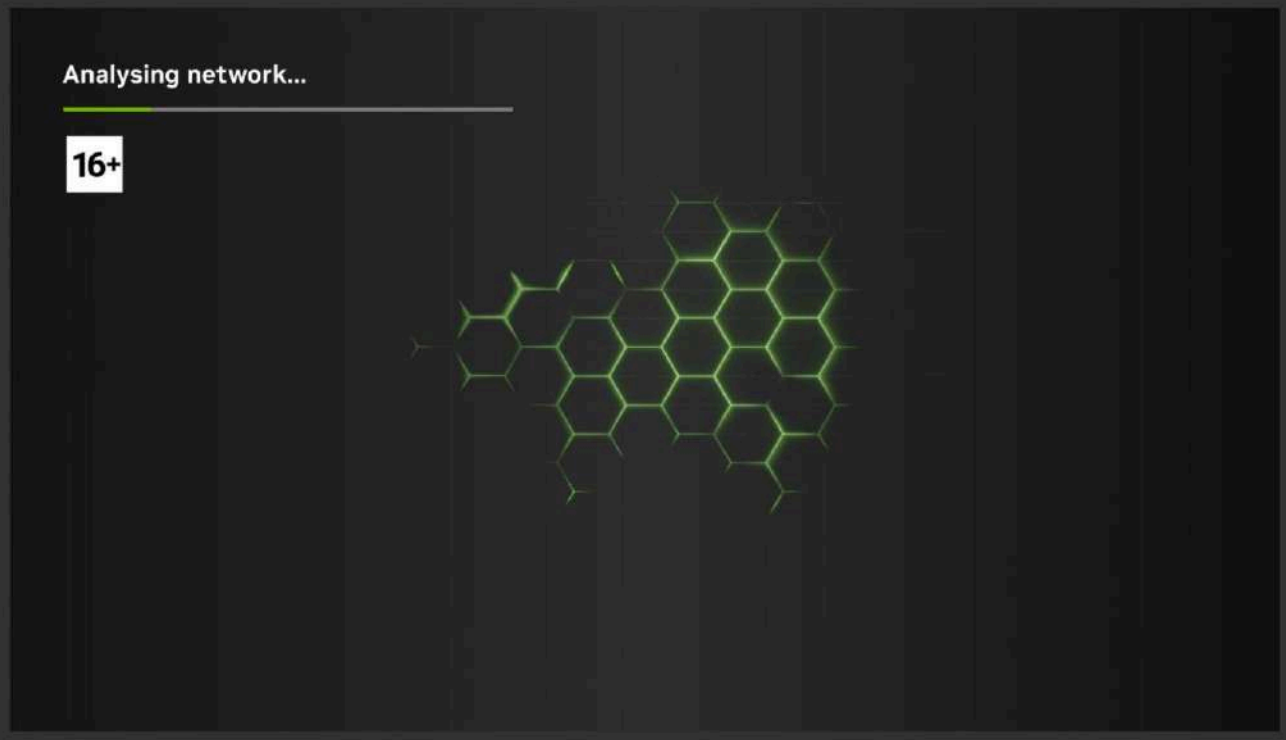

All games page page
Z- Height note
All elements are in the same layer
25 / 1803 games
My library
SORT


Evidence page
Z- Height note
Poster is on far layer
While rest is on near field layer
Assassin's Creed™
Online multiplayer | Partial gamepad
Action, Adventure, Shooter, Free-to-Play, MMO
Supported stores: Origin, Steam
Select a game store
To play this game, you must own the PC Digital Download version of it on one of the supported stores.
PLAY
+ LIBRARY
TEEN
Blood, Violence
In-Game Purchases, User Interact

**Game Loading page**

**Z- Height note**

Text, loading bar and icon are in the near layer.

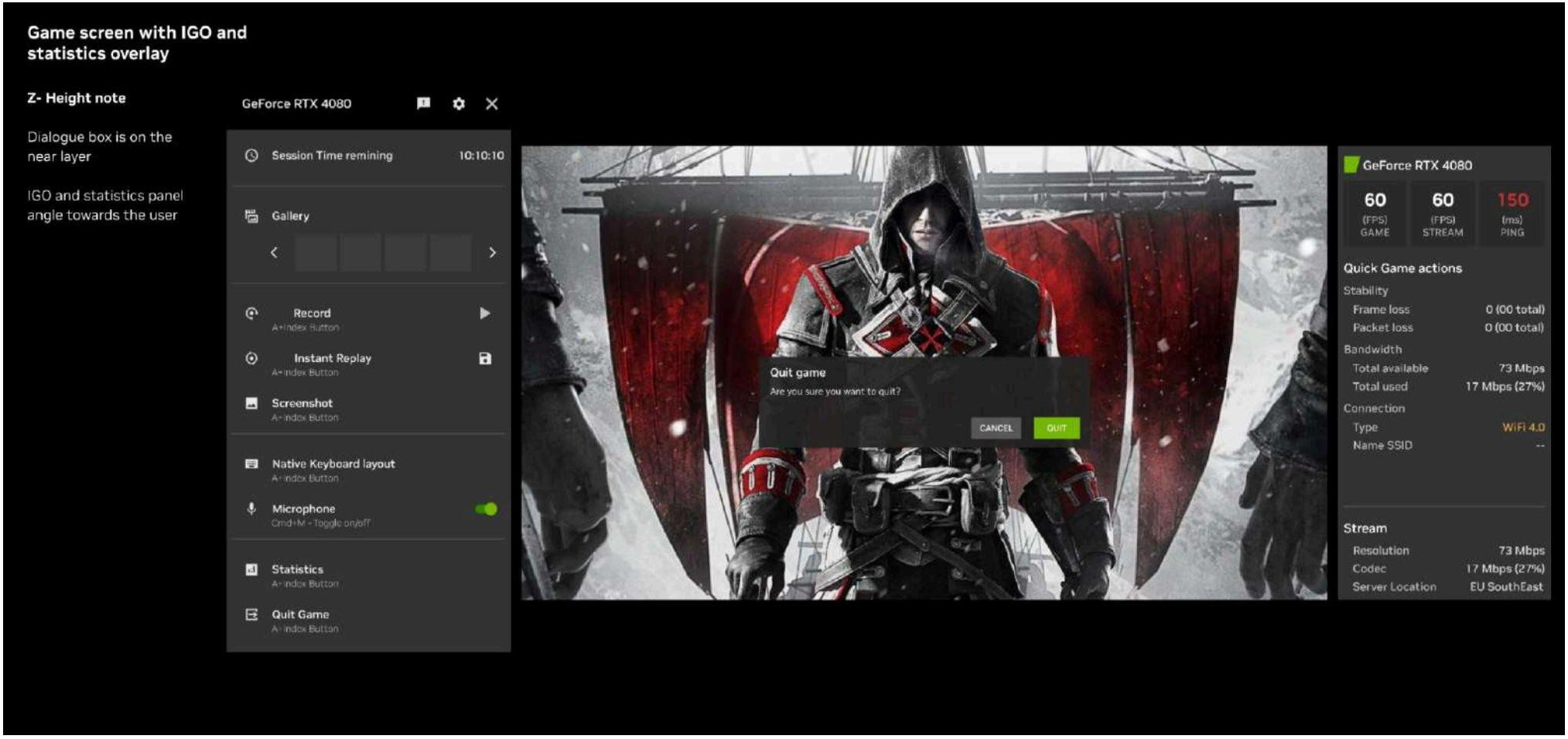


## Game screen with IGO and statistics overlay

**Z- Height note**

Dialogue box is on the near layer

IGO and statistics panel angle towards the user



## 8. Evaluation

For evaluation an user testing plan  was created similar to the user study protocol,  one to one discussion with participants while they use the prototype in VR, navigate through the interface. And understand their intuitive ways of doing things, if there are any confusion points or a better way to approach the navigation.The Estimated time was around 30-45 mins.

**Interview Script**

| | Interface element to be tested | Questions |
|---|---|---|
| 1 | **Hover states** of clickable/ active interface elements which includes : The nav bar, Game cards and see all button | • Can you tell which are the actionable buttons?<br>• Are the hover states intuitive? |
| 2 | **Marquee**<br>Appearance | • How do you feel about the Marquee? (Start with open ended question)<br>  ◦ -Placement (z position)<br>  ◦ -Gradients<br>  ◦ -Expanse |
| | Interaction : Toggling it with the side arrow buttons | • Were the buttons easy to spot and aim?<br>• Does the interaction with them feel interactive? |
| 3 | **Evidence panel**<br>Navigation and Trigger | • Was the trigger to open evidence panel intuitive?<br>• How do you return to the game cards again? |
| | Info. display | • Is the way information displayed makes sense?<br>  ◦ layering of the interface elements<br>  ◦ Graphic content (size, gradient)<br>  ◦ Background of the text |
| 4 | **All games page** | • Was it easy to open the all games page?<br>• Does the page looks to cluttered or inadequately  populated? |
| 5 | **Game screen** | |
| | Loading page | • Does the loading bar feel consistent with existing GFN UI?<br>• Any feedback / suggestion on the transition? |
| | IGO and Statistics bar | • Can you locate the IGO icon?<br>• Is the placement of IGO panel intuitive?<br>• Is the text legible?<br>  ◦ The background<br>  ◦ Contrast, size |
| | Dialogue box | • Does the pop-up feel too intrusive with reference to consistency with the existing interface?<br>• Is the text readable?<br>• Are the actionables intuitive? |

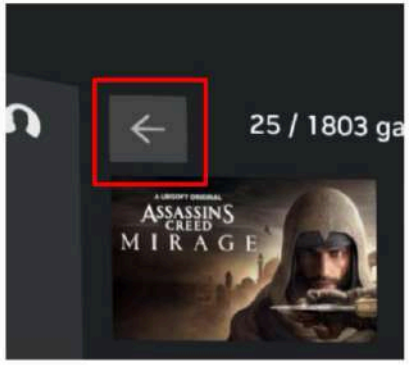
## Evaluation results

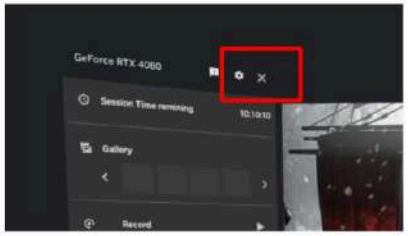
### *General navigation*

**Back and cross button**

1. It's more intuitive to have a **dedicated back button** on controllers than pointing and clicking on screen.

*" Which is the back button on controllers ? "*


### *IGO*

**Trigger**

1. The **icon was not understood** and missed by participants, appeared disjointed.
2. A **hotkey is more preferable** than an on screen option

## *Game cards - evidence panel*

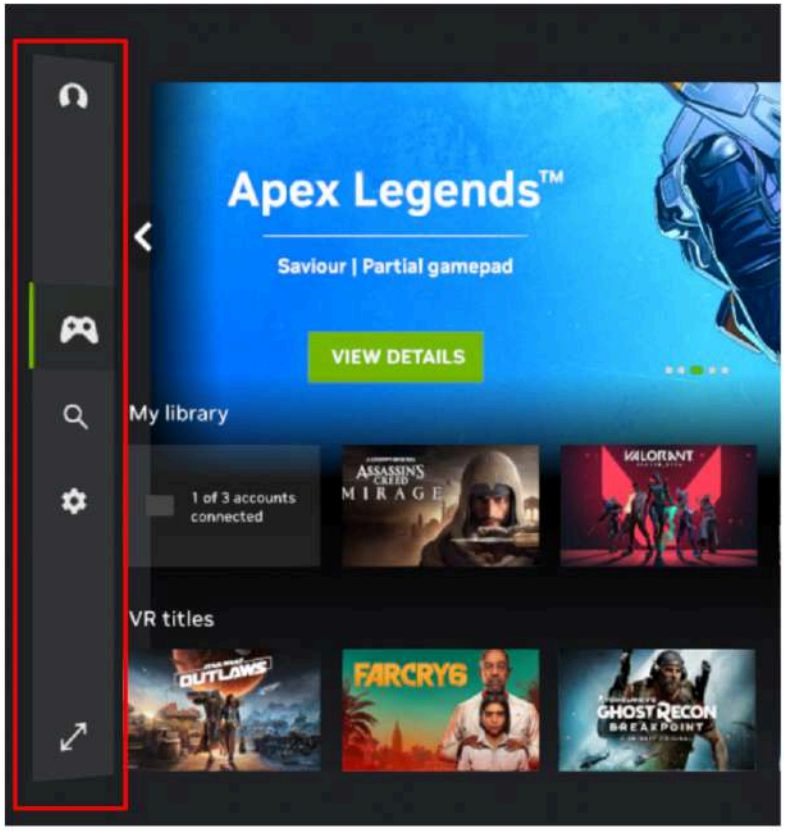
**Trigger** (Suggestion)

*" I see only the PLAY button, maybe there could be a different button for viewing details "*


## *Navigation bar*

**Perception** (Suggestion)

*" Feels like an admin software than a game software, it can be more dynamic It can collapse and reopen upon hovering "*

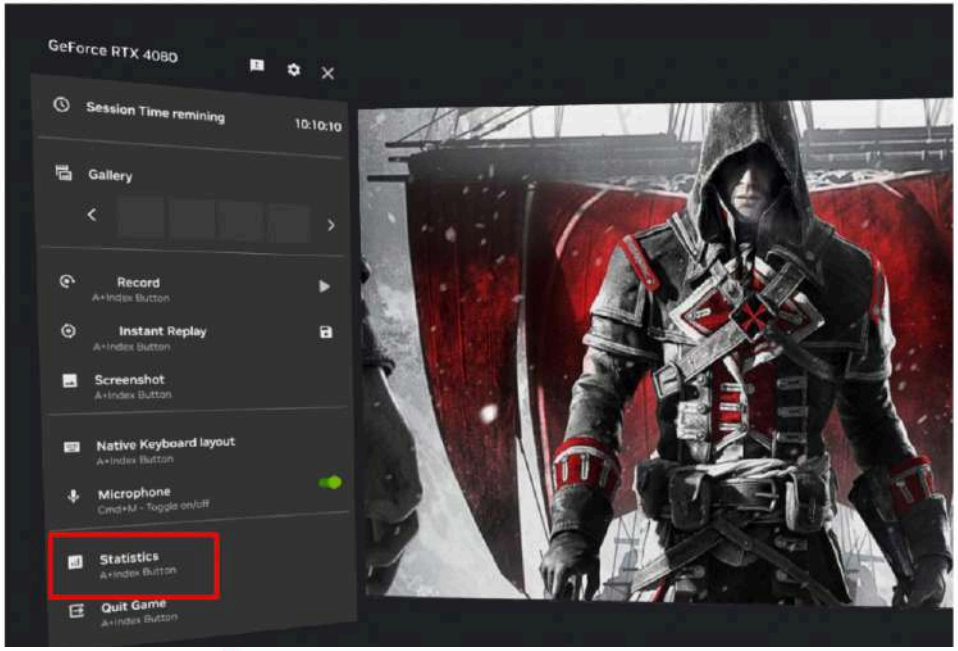


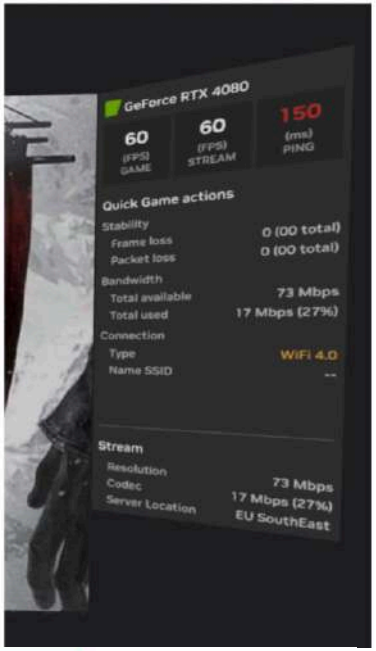
## *IGO*

**Association to statistics menu**

1. When clicked on the statistics menu, there is no feedback that the menu has opened

*"I don't know that the menu has opened or not and where, because my FOV is limited"*

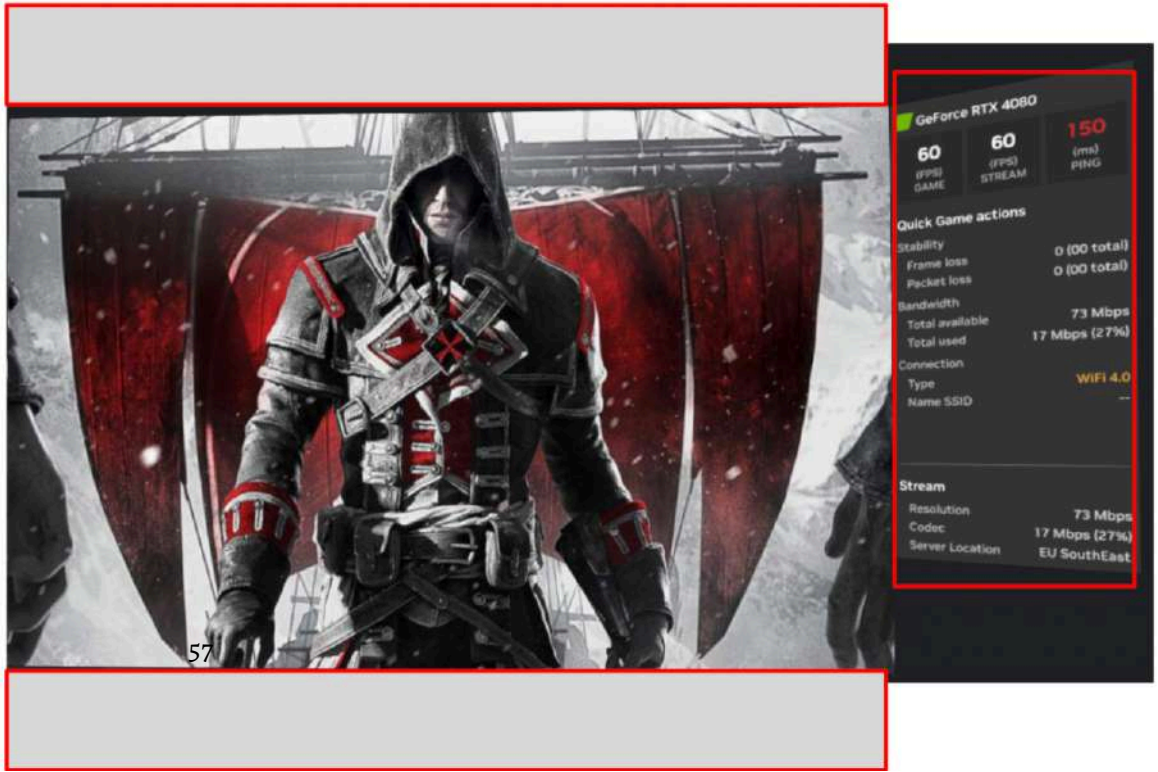



## *IGO*

**Customizability**

*"I want to place my statistics panel wherever I want around the game screen, maybe the layout as well"*



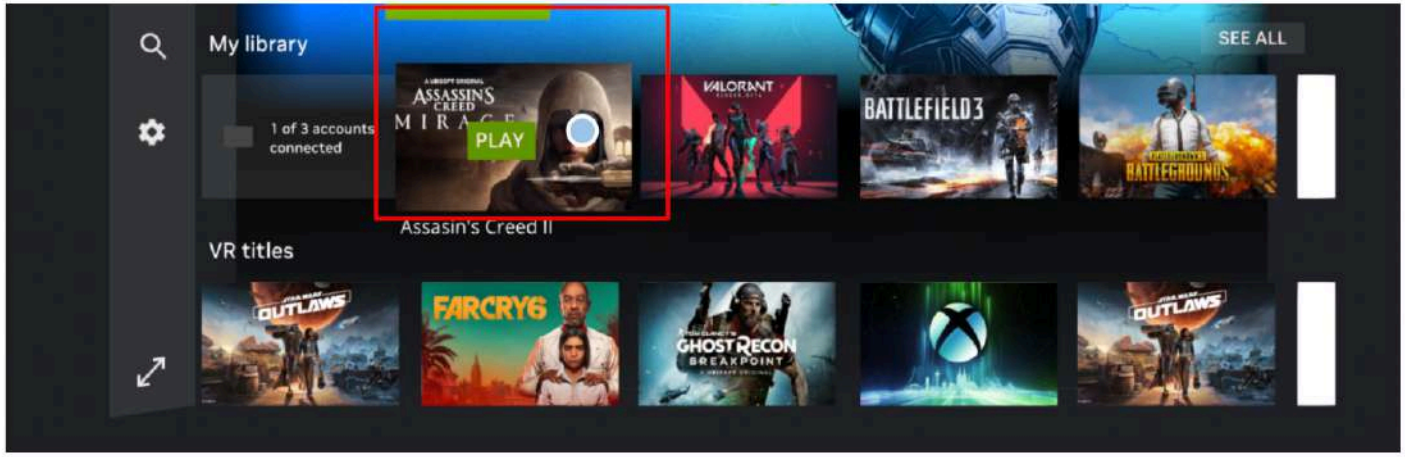
## GAME CARDS

**Visual Feedback**

1. The hover state seems **inadequately highlighted**
   -Scale can be increased more
   -Effects like shadows, glows

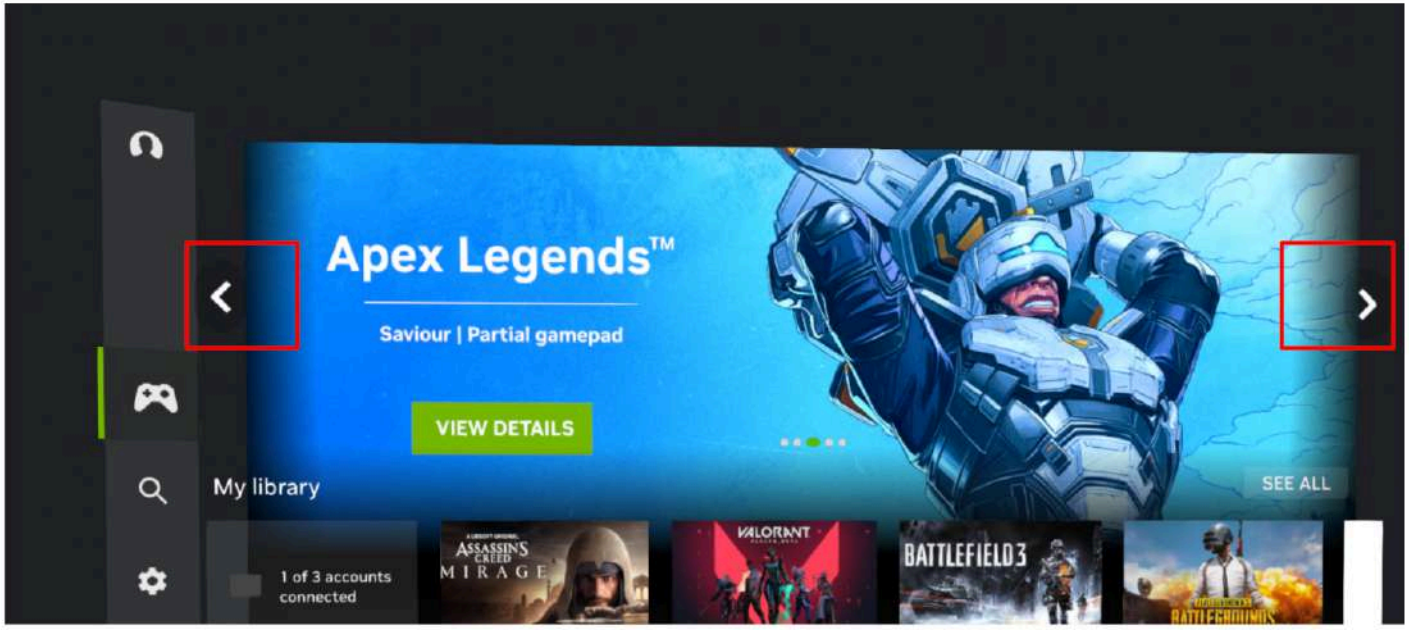
2. The first card should be opaque, creates confusion.

*" I think we can use the depth a bit more to highlight the cards "*




**Visual feedback**

1. Arrows **placement should be adjusted and aligned** according to the UI elements and perspective

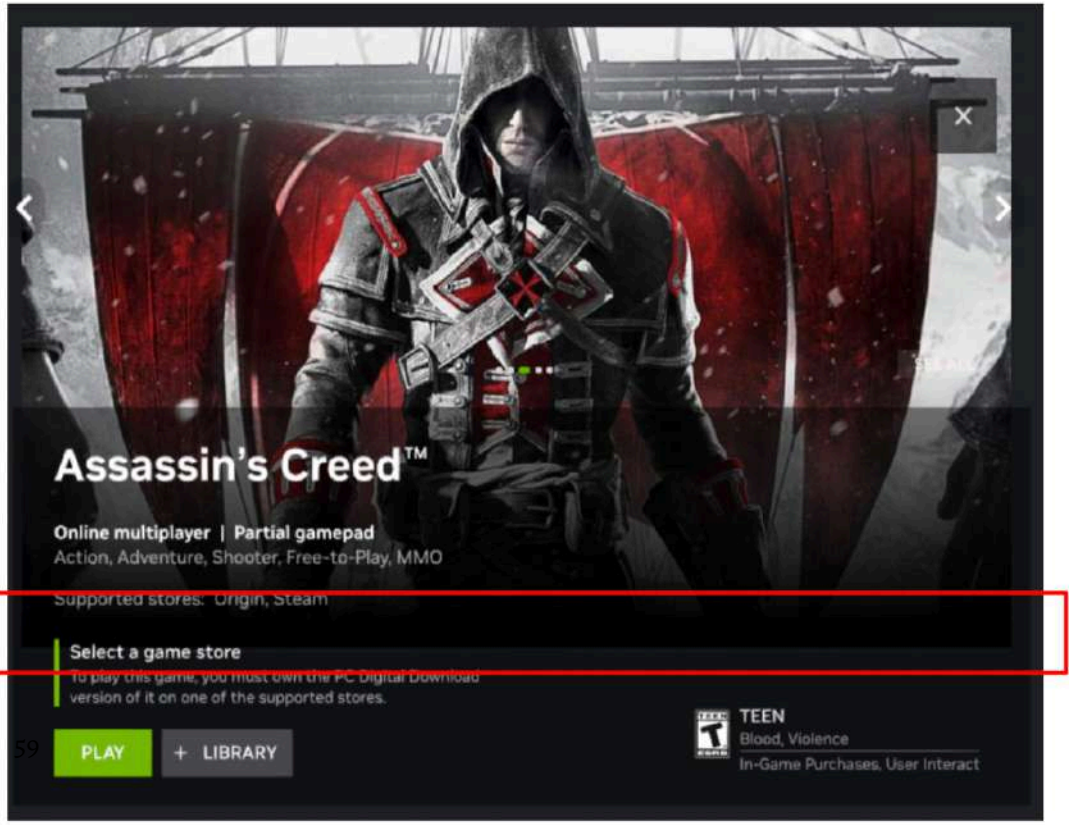


**Visual feedback** (Suggestion)

*" Since the poster is horizontally spanning so much, I think it would feel more focused if it is a little curved like curved monitor "*

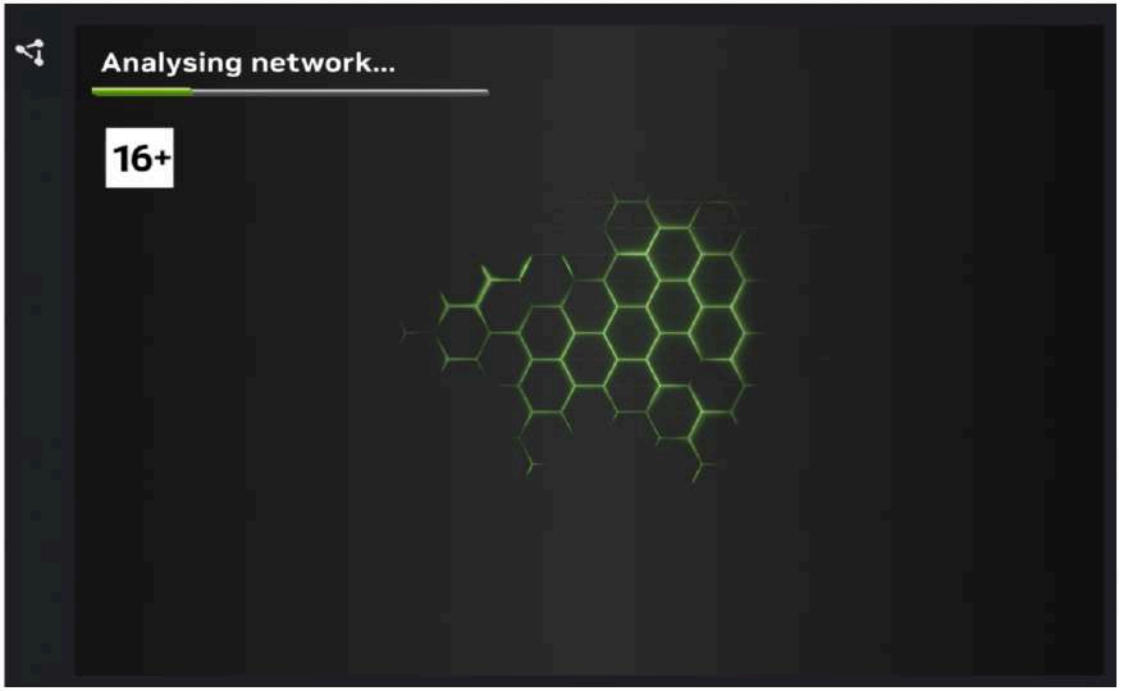

**Visual Feedback**

1. The **overlap line** of the text background and the game poster seems a **little confusing**



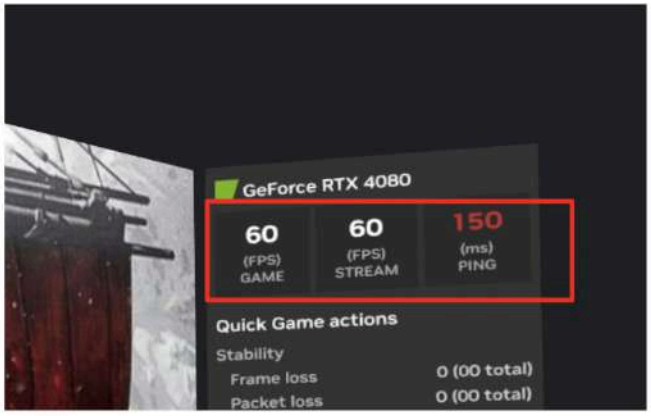
**Loading page** (Suggestion)

*" We can display some cautionary info. (Like hotkeys / do's and don'ts) for using VR in gaming "*




**Statistics menu** (Suggestion)

*" If there are graphs about how my data is performing against the time, it would be helpful, rather than just numbers "*



## *EVIDENCE PANEL*

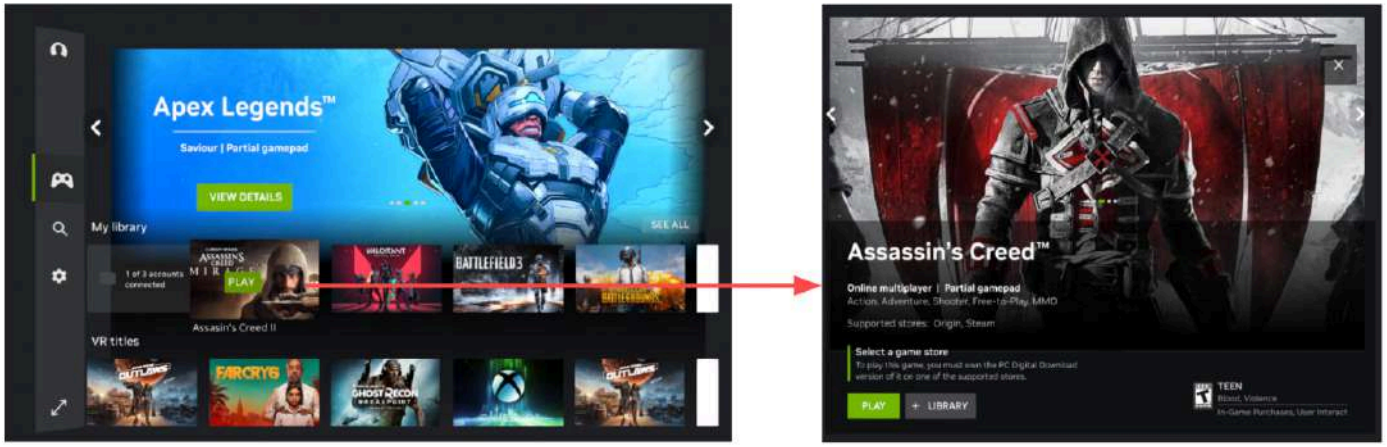
**Information architecture**

1. Opening a separate page was not preferred by **7/11** users

*" I am here to quickly browse and play my game, going to different page breaks my flow "*

*" For me some keywords are enough to judge, (adventure / shooter / etc.) maybe an image or two"*

*" When there are a lot of options then it would make sense "*



## 9. Conclusion

**Navigation**

Users wanted to have more shortcut / hotkeys for frequent navigation gestures than aim and click on specific buttons. Users felt the interface was consistent with the screen based interface hence it helped to get comfortable with the interface in no time. Users felt the Navigation was much simplified and intuitive.

**Interaction**

User's intuitive actions are derived from the conventional 'mouse-keyboard' setup. Users found the interface very friendly and welcoming in terms of spatial handling capabilities it offered. Most interaction techniques / responses were intuitive.

**Information Presentation**

Users felt the design could leverage the 3 dimensional affordances of VR such as depth, spatial perception, etc in a better way to enhance the experience. Users liked the hierarchy that was created between the display and the intractable part through depth . (Eg. Use of depth to separate the marquee from the game cards).

**Information structure**

Number of clicks was the sole priority, and users suggested the shortest path to launch the game to be more preferred.

## 3. References


[1] Gregory D. Clemenson Lulian Wang Zeqian Mao Shauna M. Stark Craig E. L. Stark*, Exploring the Spatial Relationships Between Real and Virtual Experiences: What Transfers and What Doesn't, Front. Virtual Real., 08 October 2020

[2] Rabia M. Yilmaz a, Ozlem Baydas b, Turkan Karakus a, Yuksel Goktas, An examination of interactions in a three-dimensional virtual world, Computers & Education, Volume 88, October 2015, Pages 256-267