Human Computer Interaction

Developing a navigation system for mobile-based Virtual Reality experiences.

by Maxwell Knox

Contents

1. Introduction

2. Requirements Capture and Specification

    2.1 Formative User Group Study
    2.2 Stakeholder Diagram
    2.3 Problem Scenarios and Claims
    2.4 Requirements Specification

3. Conceptual Design

    3.1 Initial Diagram and Walkthrough
    3.2 Revised Diagram

4. Scenario-Based Design

    4.1 Activity Design
    4.2 Information Design
    4.3 Interaction Design

5. Storyboards

6. Next Steps

7. Conclusions

8. References

1. Introduction

Although the concept of Virtual Reality has been around for some time, a new and exciting technological development in recent years has been the emergence of consumer-grade Virtual Reality hardware and software. There is now a large variety of device types available on the market. These devices enable new methods of accessing, and interacting with, VR software and experiences. Ranging from cardboard-based mobile phone holders, to high-end devices which incorporate room-scale tracking of headsets and controllers. Each of the VR hardware types present their own unique challenges for designers working within this medium.

This report focuses on some of the challenges faced by designers working with mobile-based VR. More specifically, this project looked at some of the different possible ways in which the navigational elements of mobile VR could be handled. The aim of the report was not to provide a definitive solution to this issue, but rather to serve as useful starting point for further work and research into this area.

Before we begin, it is helpful to define more clearly what is meant when we talk about "mobile-based VR". Mobile-based VR generally requires the combination of two devices: a VR-capable smartphone, and a VR head mounted display (HMD). The HMDs designed for working with mobile devices are relatively simple, and are cheap to produce and purchase. They are often referred to as "Cardboard" devices, as they tend to be manufactured using inexpensive materials. They can serve as a good introduction to VR, and allow consumers to experience VR for a relatively low cost, provided they already own a capable smartphone.

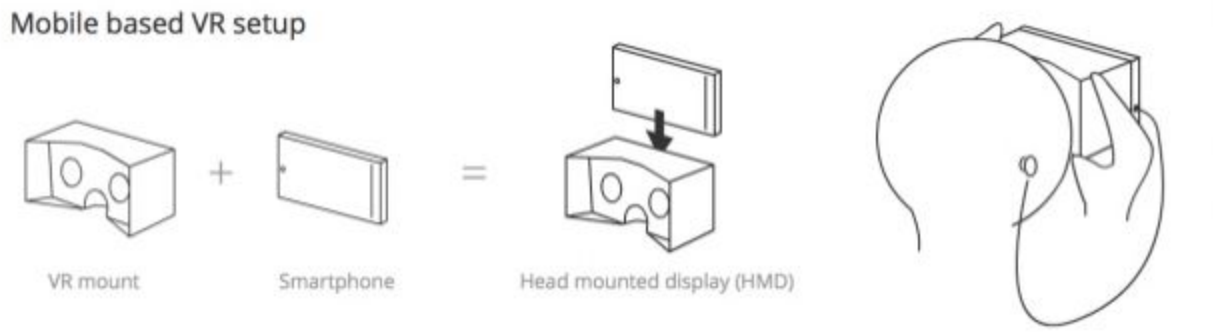


Fig. 1.0 - Mobile-based VR setup

One of the challenges facing designers working on experiences tailored for mobile VR, is the lack of input methods available to the user. The main method for interaction a user has is their gaze. Mobile VR experiences can be designed to react to the direction the user is facing, and

where their focus is centered. I wanted to use this report to investigate how a designer might approach the development of a solution for allowing a user to move around within a VR scene, using only their gaze as the interaction method. In order to ensure that the design process remained relevant to the user experience, a group of potential end-users was recruited to participate in the study. Input and feedback was sought from the user group at various stages of the design process, and alterations were made based on this feedback.

2. Requirements Capture and Specification

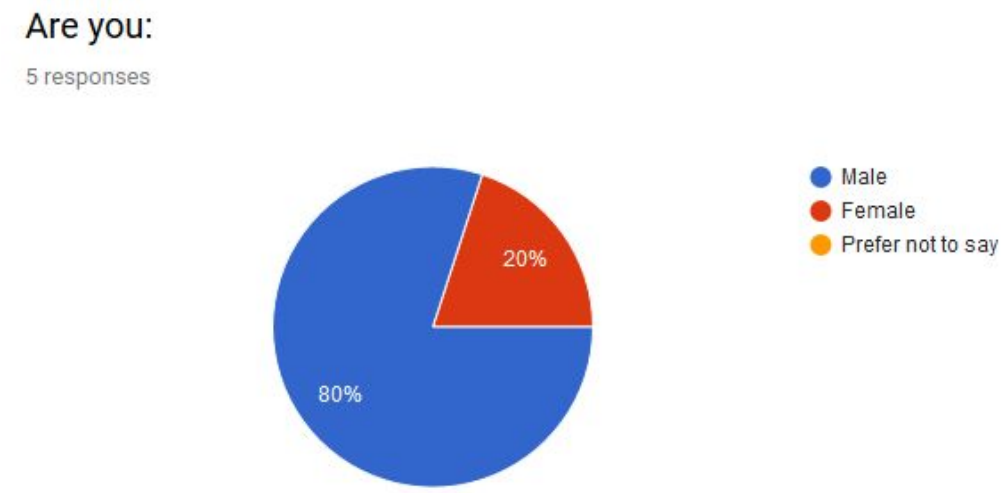
Before moving on to creating any design materials or assets, it was necessary to seek input from the user group. In order to help create a set of requirements for the project, users were asked to answer a number of questions relating to their previous experiences with VR, their general level of technological understanding, and what they might expect or desire from a VR experience. I created a stakeholder diagram to help illustrate what parties might be involved in the creation and use of a mobile VR app. A number of scenarios were written, and a claims analysis was conducted on each scenario. The user group provided feedback on the scenarios and claims. Finally, a set of requirements were defined, which would inform the design process.

2.1 Formative User Group Study

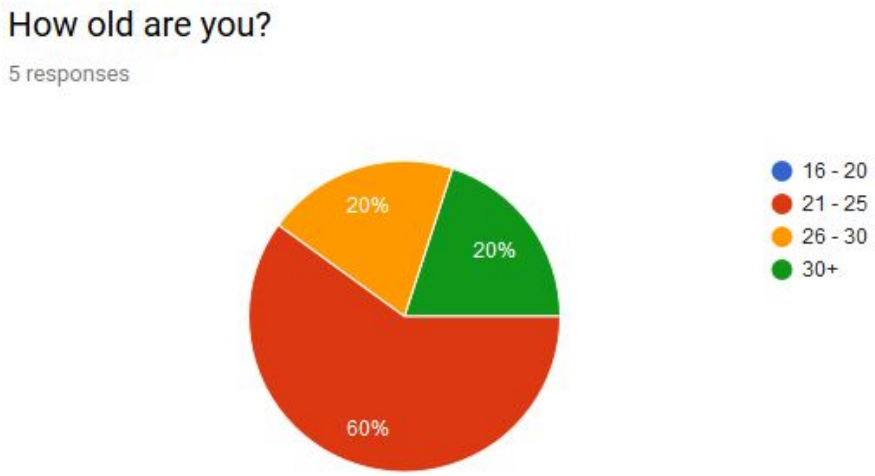
Each user participating in the study was asked to fill out a short questionnaire. The questions were intended to provide some insight into the characteristics of the user group. I wanted to know what their level of experience was with regards to VR, and also technology in general. I used Google Forms to create the questionnaire and asked the participants to fill it in online.

Survey Results:

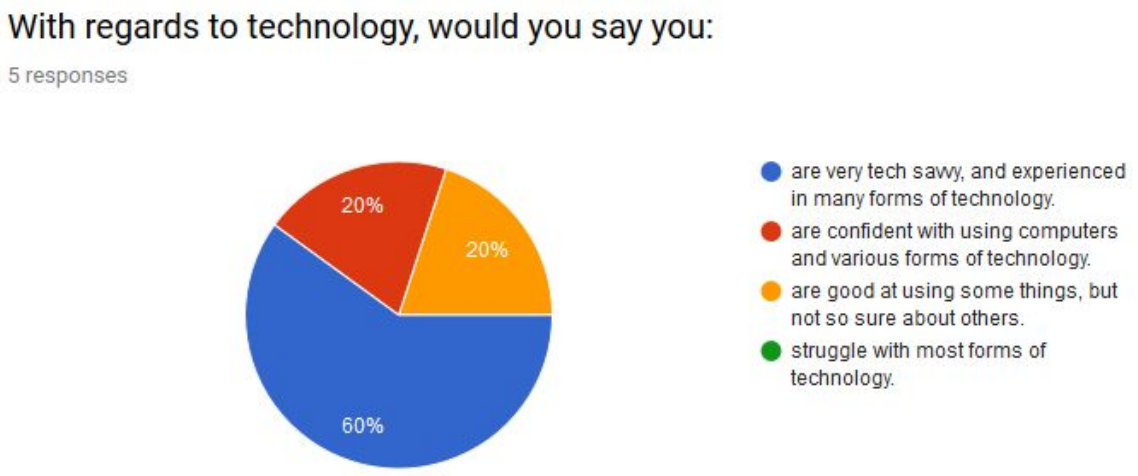
Question 1:



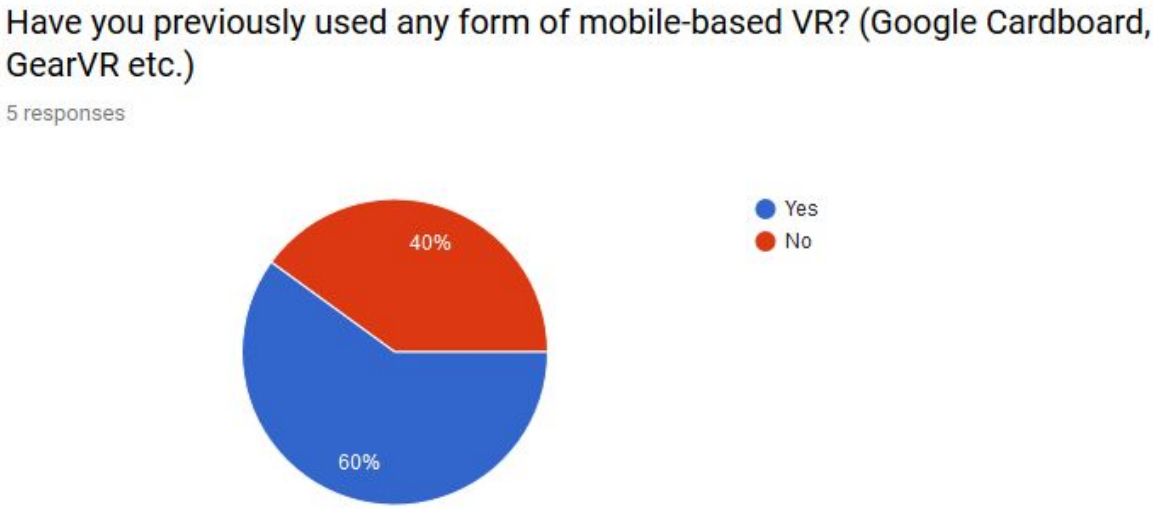
Question 2:



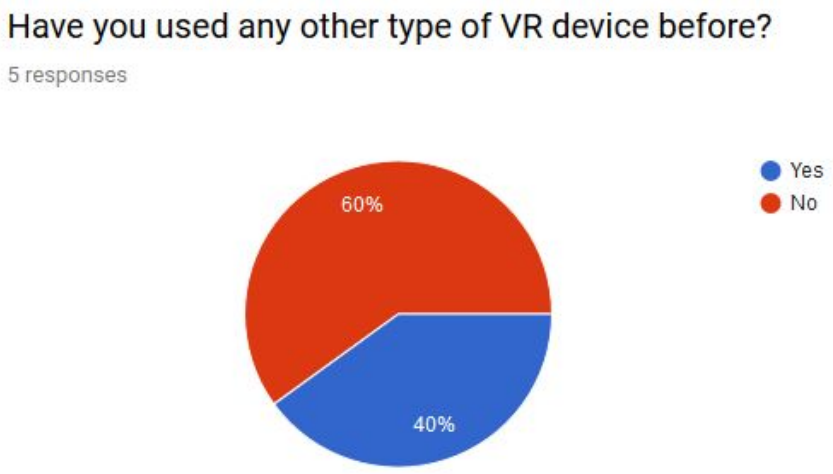
Question 3:



Question 4:

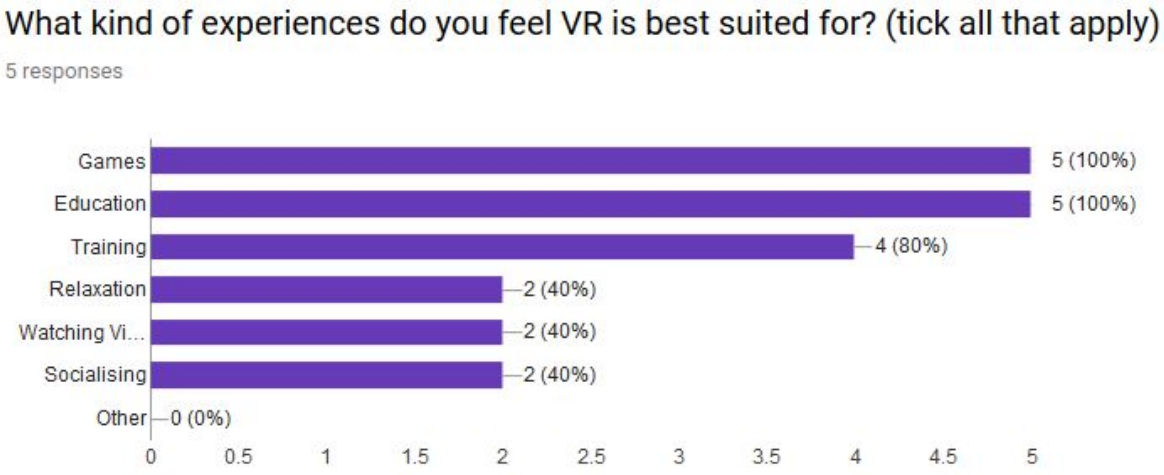


Question 5:

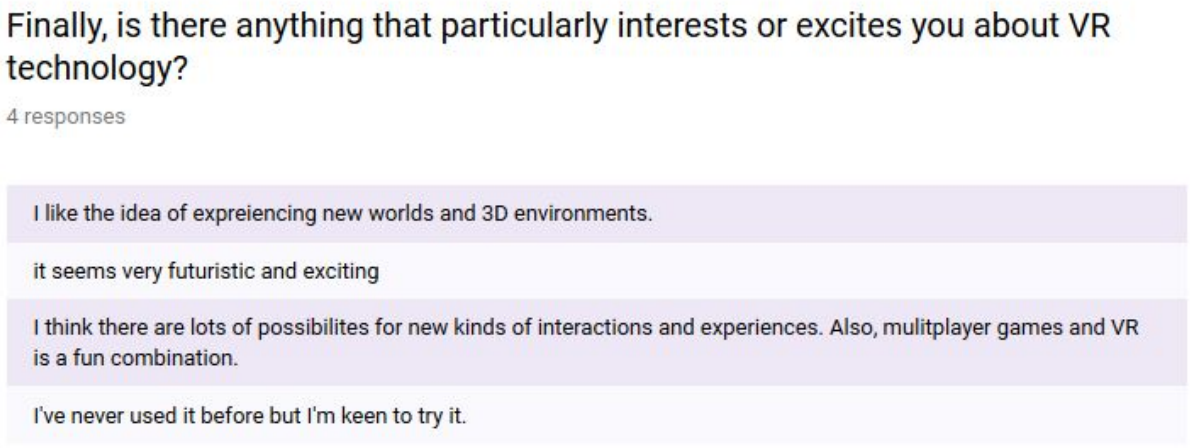


Question 6:

Question 7:



Question 8:



Analysis:

Four of the five participants were under the age of 30, and four of the five described themselves as being either very tech savvy or confident in using a variety of forms of technology. Four out of the five had also experienced using some form of VR device. Of the four, three had used mobile based VR and two of the participants had used other kinds of VR devices (The Oculus Rift and HTC Vive). All of the participants believed that VR was a platform well suited for Games and Educational experiences. VR as a training device also scored highly. All of the participants seemed to be interested and excited by the concept of VR, and the person who had not used VR before remarked that they were interested in doing so.

2.2 Stakeholder Diagram

The stakeholder diagram shows the different parties involved in the creation and use of a mobile-based VR app. It highlights some of the relationships that the parties involved have with the app at various stages of its life-cycle. The diagram serves as a useful reference during the design phase of a project of this type.

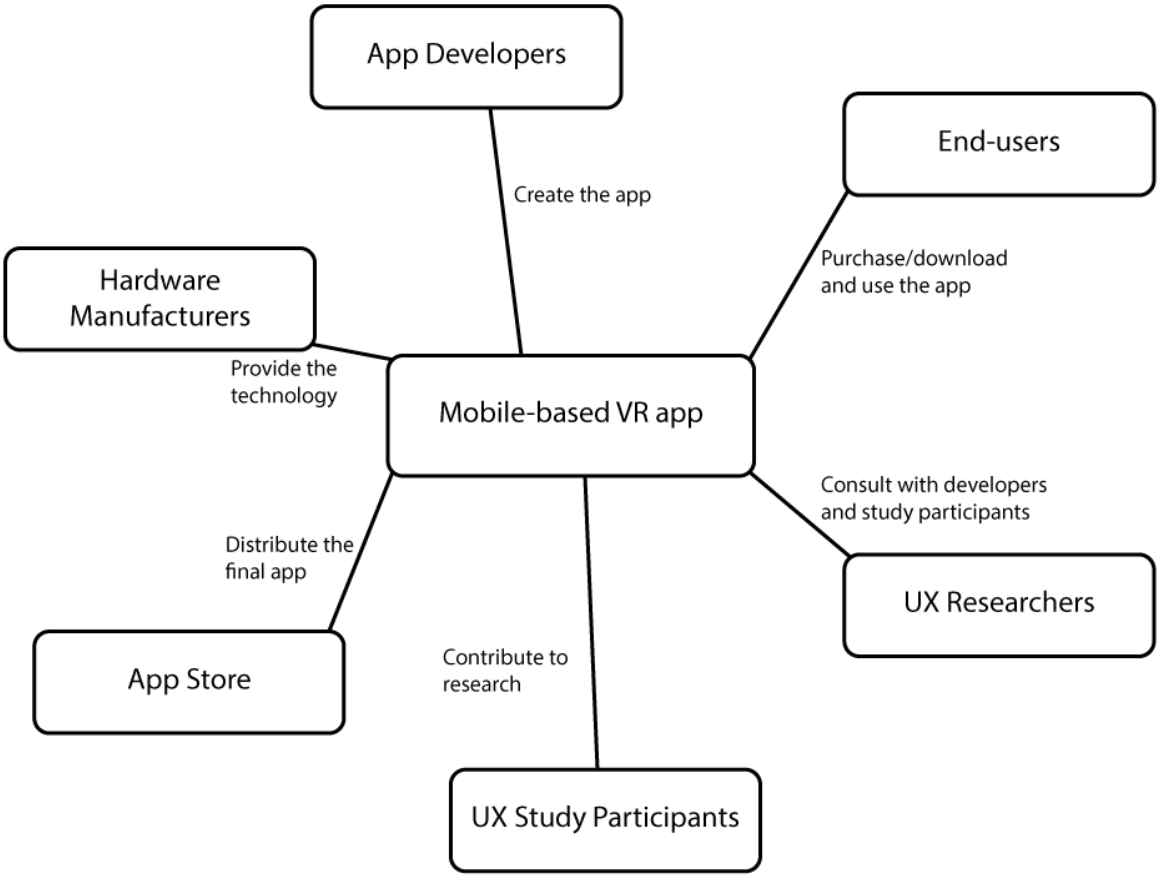


Fig. 2.1 - Stakeholder Diagram

2.3 Problem Scenarios and Claims

The next step was to create a set of initial problem scenarios and claims. These were based around the focus of the report - navigation in mobile-based VR experiences. I developed these scenarios and claims, then discussed them with the user group to see if there was any additional input that they could provide.

Context for each scenario was provided by creating a persona or user profile. The characteristics of this persona were derived from the information learned about the user group in the previous task and also the stakeholder diagram in section 2.2. The tables below show a description of the persona, a problem scenario, what the features of the scenario are and the pros and cons (claims) of each. I discussed these with the group and updated the tables based on their feedback. Contributions made by the group are indicated by red coloured text.

Example 1:

This example provides a scenario that gives a general overview of how the proposed navigation system might be incorporated into a mobile-based VR experience.

Persona	**Scenario**
Actor: Susan is a student of Digital Media at the Robert Gordon University. She has recently purchased a new smartphone and wants to try out some of its features and capabilities. Some of her fellow students have been talking a lot about their experiences with VR and she is keen to try it out. She buys a cheap cardboard holder for her phone with the intention of testing out some VR experiences. **Background:** 4th year honours student. Interested in new technologies. She's comfortable using most kinds of devices and usually picks new things up pretty quickly.	The first mobile VR app she wants to try out is a virtual museum exhibition. The layout of the app consists of a large room with various points of interest (exhibits) scattered around.

Situation Features	**Pros (+) and Cons (-)**
A mobile phone with cardboard holder.	+ Cheap and affordable VR experience + Easily accessible - can be used almost anywhere. + Requires no further special equipment - Usually requires access to the internet. - Requires a smartphone, which can be

	expensive
A large virtual room with various points of interest.	+ Lots of content can be contained within the large room + Good way of contextualising information - Must be careful not to overload users with too much information or visual stimuli.
Navigation system	+ Allows the user to move around the room. + Being able to move around lets the user see more content. + Allows the user to be an active participant in the experience rather than a passive observer. - Potential for disorientation of the user if not handled correctly. - User must be made aware that they can move around in the scene.

Example 2:

In this example we looked more closely at the navigation system itself and what might be involved in implementing such a feature.

Persona	**Scenario**
Actor: James is a mobile app developer. He is doing some research into creating a VR app for the first time. **Background:** Has lots of experience working on 2D apps. He has some experience doing 3D modelling work, this however, is his first project involving mobile-based VR.	He would like to create a VR app that lets users move around within a virtual museum. He is trying to decide on what the best method of enabling the user to travel from one exhibit to another is. He has to bear in mind that the only way a user can interact with the scene is by focusing their gaze on objects within the scene.

Situation Features (navigation ideas)	**Pros (+) and Cons (-)**
The user looks at an exhibit and moves towards it.	+ The user can find something interesting in the room and move towards it. + Exhibits will likely be visually attractive/interesting + The exhibits fit in well with their surroundings (i.e. within the context of the room). - It might not be obvious to the user that looking at an exhibit will make them move towards it. - Must program the animation of the user moving towards the exhibit
The user looks at a navigation "node" in front of an exhibit and moves towards it.	+ The navigation node provides a clear target for the user to focus upon + Provides consistency to the navigation system's method of interaction + Can be visually distinct and draw attention. - It might break the user's immersion by having an unnatural object in the scene. - The animation of the user moving towards the node has to be programed. - Purpose of the node might not be obvious to the user.
The user looks at a navigation "node" in front of an exhibit and "teleports" towards it.	+ The navigation node provides a clear target for the user to focus upon + Provides consistency to the navigation system's method of interaction + Can be visually distinct and draw attention. + Developer doesn't have to program the movement animation. - It might break the user's immersion by having an unnatural object in the

	scene. - Purpose of the node might not be obvious to the user. - The "teleportation" mechanic may be jarring for the user.

2.4 Requirements Specification

Based on the discussions surrounding the scenarios and claims I have created a short table that describes some of the key requirements for the gaze-based navigation system.

Table Name: Requirements Specification

ID	Requirement Name	Description	Functional/Non-functional
1	Gaze-based interaction	Users must be able to interact with the VR scene by using their gaze to perform actions.	Functional
2	Navigation	Users must have the ability to move around the scene.	Functional
3	Navigation Nodes	The navigation will be handled by navigation "nodes" within the scene. Users can gaze upon a particular node in order to move towards it.	Functional
4	Call-to-action	The navigation nodes must be visually distinct from the rest of the scene, and their purpose clear.	Non-functional
5	Tutorial	Users must be informed in some way of the interaction method - the purpose of the nodes and how to interact with them	Non-functional

3. Conceptual Design

3.1 Initial Conceptual Design Diagram

The conceptual design diagram below illustrates the functionality of the navigation system and the steps required in order for a user to perform the task - moving from point A to point B within the VR scene.

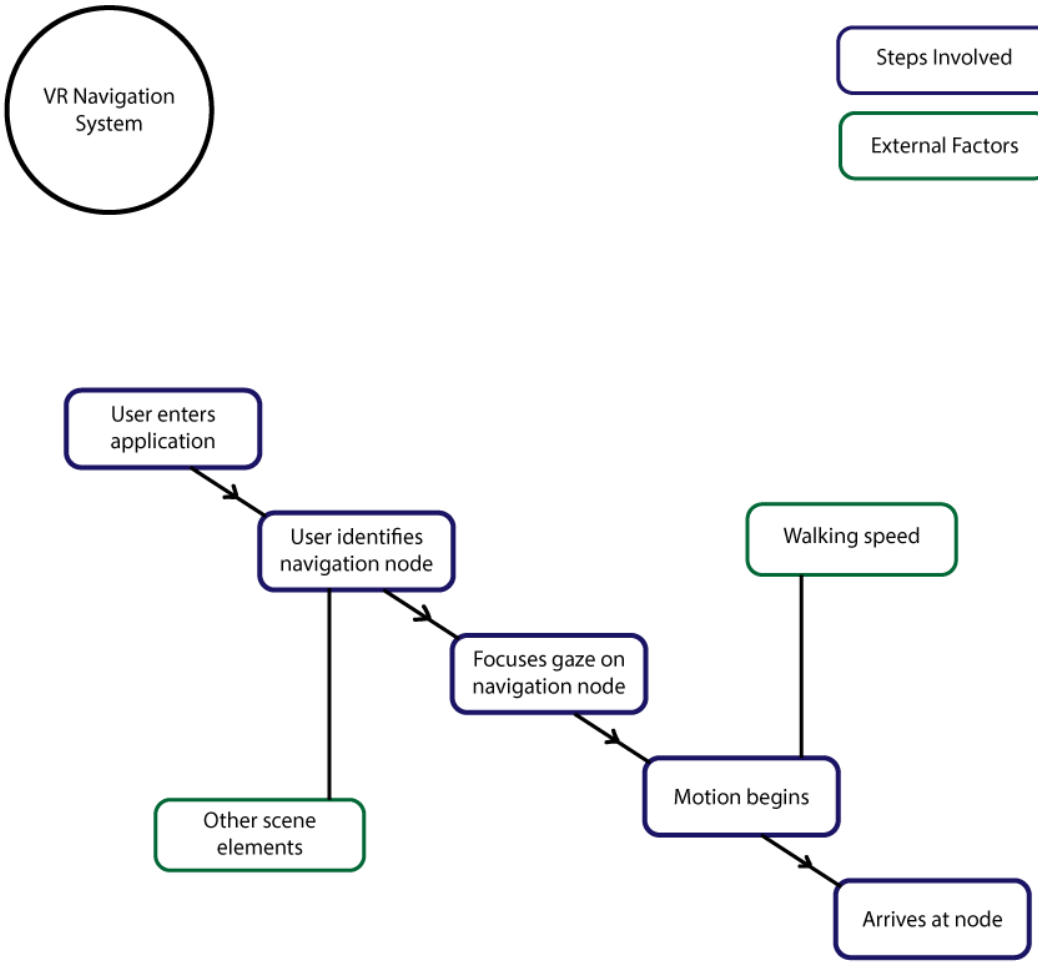


Fig. 3.0 - Initial Conceptual Model

This initial conceptual model was shown to the user group, and the members of the group were asked to perform a cognitive walkthrough. The purpose of the walkthrough was to help identify whether or not the necessary steps to complete the task would be clear and obvious to users. The task has been broken down into a series of subtasks and each was evaluated in turn.

The task: navigating from the start point, to a node within the scene.

1. The user enters the application.
2. The user identifies a navigation node.
3. The user focuses their gaze on the node.
4. The user/camera begins to move towards the node.
5. The user arrives at the node.

Evaluation:

1. When discussing this step with the user group, it was identified that users of the app needed to be made aware of the interaction method and also how to identify a node within the scene.
2. In order to aid with the identification of a node within the scene, it must stand out from the other objects in the scene. This could be achieved by giving the node a colour that contrasts well with the other elements of the scene. Another suggestion was adding some form of animation to the node, such as having it slowly rotating or hovering up and down.
3. To help the user direct their gaze and to provide some form of visual feedback, it would perhaps be a good idea to include a cursor/crosshair in the center of the screen.
4. Before the movement begins, it would be useful to have a short delay, or activation period. The idea behind this is that if the movement began as soon as the user looked at a node, then the likelihood of a user activating a node by mistake would be very high. The user could be looking around the scene and happen to glance over a node, activating the movement to that node unintentionally. Instead it was proposed that a user must focus their gaze on a node for three seconds before the movement took place. The cursor could also be animated during this time to indicate to the user that the activation was taking place.
5. After gazing at the node for three seconds, the movement begins and the user moves towards the node at a walking pace.

3.2 Revised Conceptual Design Diagram

I revised and updated the conceptual model based on the results of the walkthrough with the user group.

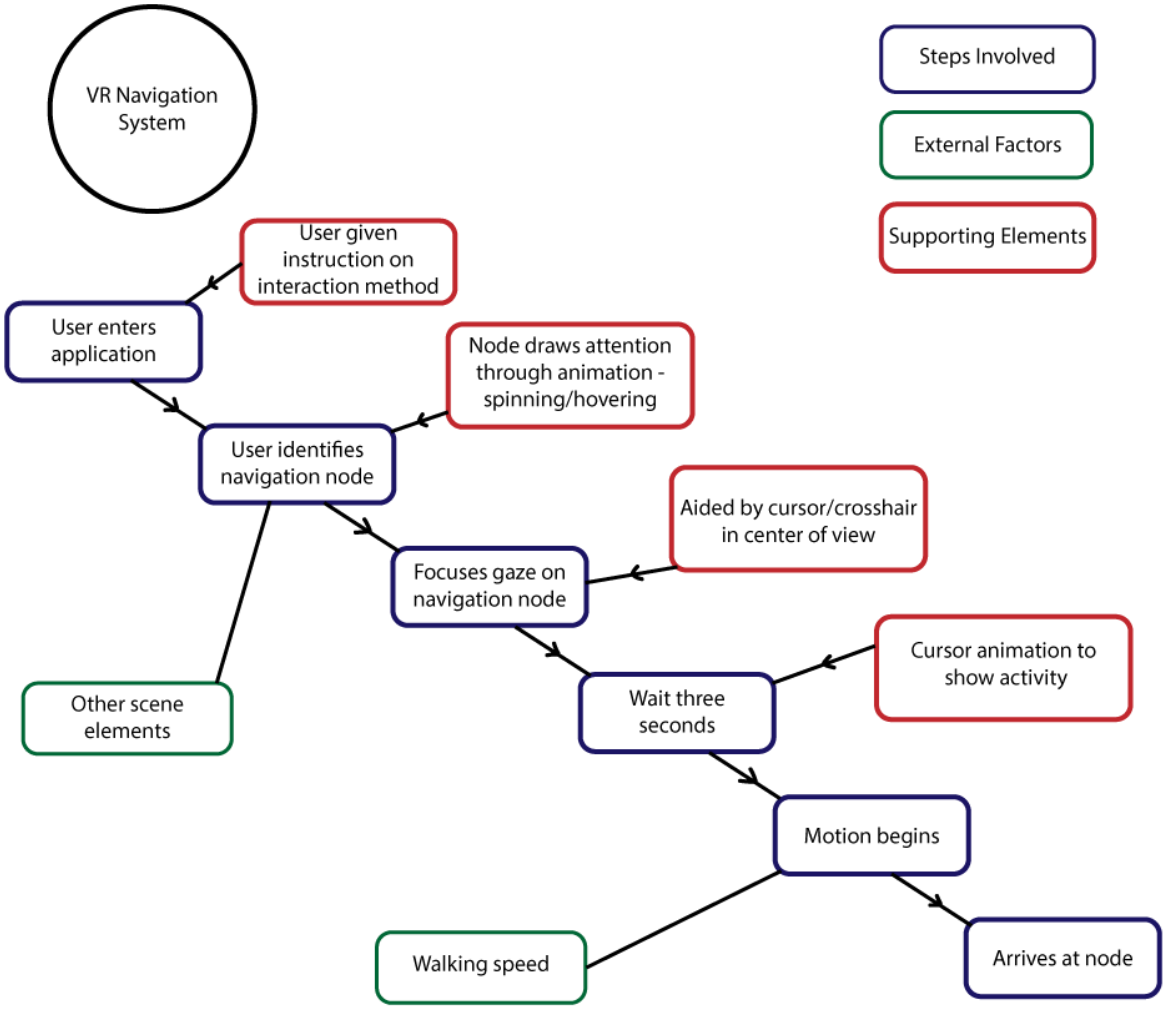


Fig. 3.1 - Revised Conceptual Model

4. Scenario-Based Design

WIth a mostly complete conceptual model in place, the next step was to provide more detail to the various elements of the design. Using scenario-based design methodologies I went on to provide a more detailed description of how the navigation system would fit into different situations in which it might be utilised. I knew that certain information needed to be conveyed to the user about the navigation system, so I clarified that further during this stage also. I then created some wireframes to help depict how a user might interact with the navigation system.

The scenarios were discussed with users, and as before, their contributions to this task are shown as red coloured text.

4.1 Activity Design

The navigation system will be an important component of a mobile-based VR app. Although the specific nature and context of the app is not defined in this report, it is still useful to consider how the navigation system could be integrated as part of a more complete system. When creating scenarios for this task I considered a number of different potential applications that might require a navigation system as a part of their design.

Example 1:

Scenario: A developer has created an educational mobile-vr app. The purpose of the app is to teach people about the planets and moons in the solar system. Users can travel around the solar system and learn about each celestial body by using the gaze based interaction system, inherent to mobile-vr experiences. The app requires a navigation system based on nodes to enable users to travel around effectively.
Claims: + Nodes can be tailored to fit within the context of the application. + Nodes can be visually altered to provide metaphors relating to travel, and in this context, space travel. A node could be represented by a 3D model of a space station or landing pad, for example. - In order to enable the nodes to fit well aesthetically within a space-themed application, some extra work may be required. Creating 3D assets/animations etc.

4.2 Information Design

An important aspect of the navigation system's design is whether or not its purpose will be clear to users when they view it in the VR scene. During the cognitive walkthrough, the user group discussed the idea that the purpose and functionality of the navigation system needed to be made clear to users. The scenarios below present some different options for achieving this requirement.

Example 1:

Scenario:

The user has to figure out the navigation system for themselves.

Claims:

+ Encourages exploration
+ Strong metaphors can make this easier
+ Reduces chance of breaking immersion

- It is possible that the user will never figure out how the navigation system works and become frustrated or give up entirely.

Example 2:

Scenario:

As a user enters the VR app they are greeted with an information panel. The panel contains an image of a navigation node and a text description of its purpose e.g. “Welcome to this VR application, gaze at the navigation nodes to move around the scene!”

Claims:

+ Makes the purpose of the nodes in the scene clear to the user.
+ Users can return to the panel should they need reminding, or further clarification.

- The VR medium is not best suited to displaying lots of text, especially on mobile devices where quality is limited by factors such as screen resolutions and the overall quality of cardboard holders.
- Panels displaying text may be an unnecessary distraction for users.

Example 3:

Scenario:

As a user enters the VR app they are greeted by a voiceover that explains to them how to interact with the scene.

Claims:

+ Doesn't rely on displaying potentially unreadable text.
+ Less immersion-breaking

- Excludes users with hearing impairments.

The scenario discussed in the first example is an attractive one because it requires the least amount of work to be implemented. It also has some benefits in that the VR experience is made more immersive by not including any kind of tutorial elements. There is however, the risk that the user may never be able to figure out how to interact with the navigation nodes. The second example is useful because it provides information to the user, and the information panel could be integrated into the scene in a manner that was sympathetic to the context of the environment - an information board in a museum, for example. The final example describes an audio voiceover that guides the user towards performing the correct action. This method has many advantages, however the main drawback is that it might exclude users who had a hearing impairment. I propose that the most user-friendly solution might incorporate both audio and text elements to guide the user toward taking the intended action.

4.3 Interaction Design

During this section the group looked at various ways in which the interaction could be made more user friendly. We discussed how the navigation nodes might look and behave and also how the crosshair component might be integrated.

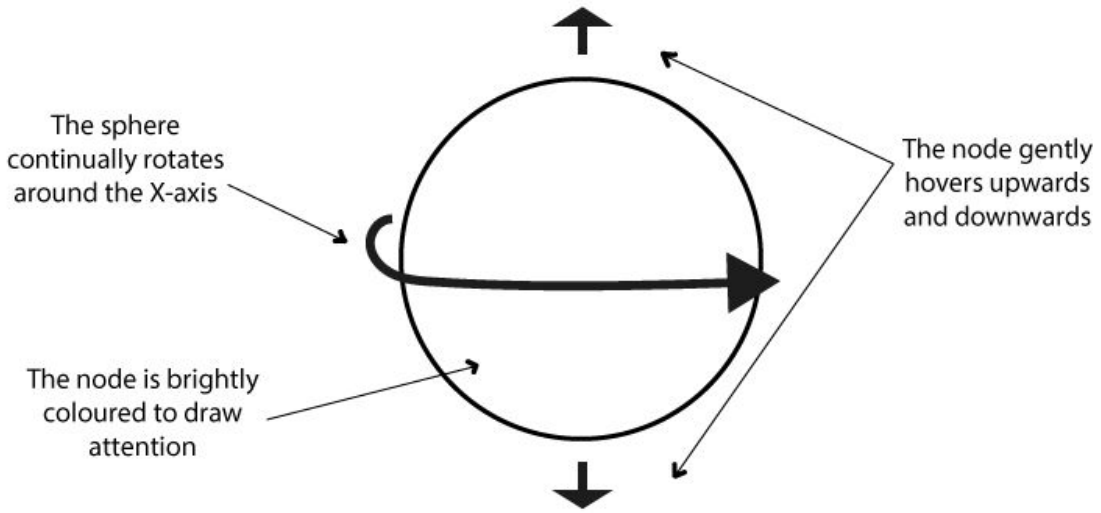


Fig. 4.0 - Node Properties

After discussion with the user group it was decided that the node could be made to stand out from the other objects in the scene by giving it animation properties such as movement and rotation. Making sure the node was brightly coloured and stood out against other elements of the scene was also thought to be an important factor to consider.

Different options for the design of the cursor were discussed. I came up with a few different designs for the cursor and asked the group to choose the one they favoured the most.

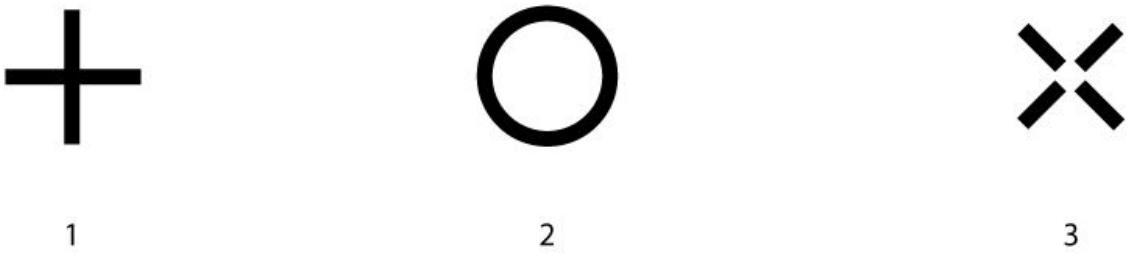
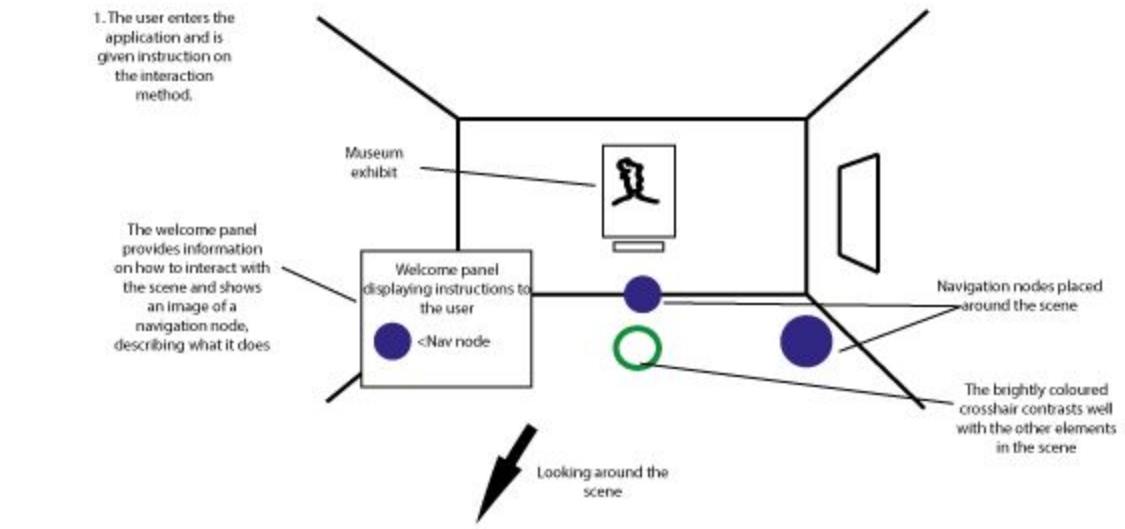


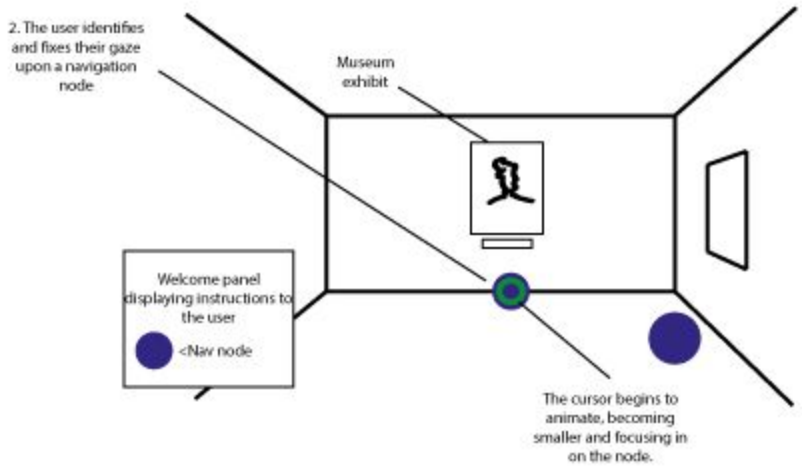
Fig. 4.1 - Cursor Designs

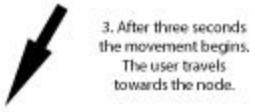
The group were overwhelmingly in favour of the second cursor design. The group commented that the circular design would allow the user to more easily focus their gaze, while also obstructing the least amount of information. The circular cursor would allow users to see what was behind the cursor more easily.

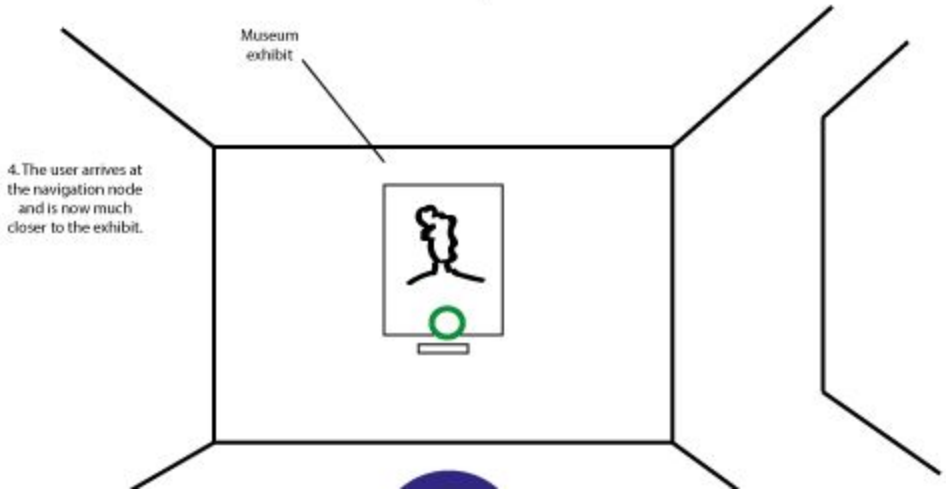
5. Storyboards

To further illustrate the steps involved in the task of using the navigation node, I created a set of storyboards.


1. The user enters the application and is given instruction on the interaction method.
Museum exhibit
The welcome panel provides information on how to interact with the scene and shows an image of a navigation node, describing what it does
Welcome panel displaying instructions to the user
<Nav node
Navigation nodes placed around the scene
The brightly coloured crosshair contrasts well with the other elements in the scene
Looking around the scene


2. The user identifies and fixes their gaze upon a navigation node
Museum exhibit
Welcome panel displaying instructions to the user
<Nav node
The cursor begins to animate, becoming smaller and focusing in on the node.


3. After three seconds the movement begins. The user travels towards the node.


Museum exhibit
4. The user arrives at the navigation node and is now much closer to the exhibit.

The storyboard helps to illustrate the processes involved, and provides clarity to the conceptual model.

6. Next Steps

Following on from the design work conducted in this report, the next step would likely be creating a prototype version of the navigation system. The prototype could then be further tested by the user group to see if what has been proposed will actually become viable in practice. Should any further recommendations be made, or issues highlighted by the user group, the creators of the system could return to the design phase and iterate on the original design specification.

7. Conclusions

This report sought to lay the groundwork for the design and implementation of a mobile-based VR navigation system. The task has been a fun and challenging experience and the input provided by the user group has certainly shaped the outcome of the final report. The users provided valuable feedback at various stages of the design process and a proposed solution has been created based on the principles of user centered design.

Something I do feel that could be improved however, is the composition of the user group. Whilst they have all provided valuable input and feedback during the design process, it must also be noted that all of the participants were drawn from a university degree course centered around technology. Ideally, the user group would be composed of a more diverse collection of potential users, in order to produce an outcome that more truly reflects the needs and experience of users in the real world.

8. References and Figures

Fig. 1.0 - Mobile based VR setup:

Mozilla Developer's Network (2016) [ONLINE] Available at: https://developer.mozilla.org