Investigating of perceived wayfinding based on the effects of zoning layout in games

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Abstract:
This study has explored different types of wayfinding techniques and elements that can be used to help people navigate in both the real world and in virtual environments. As well as three ecological models, two of them (multiple nuclei and sector theory) were designed and tested to see if the zoning layout of the models affects the participant's wayfinding ability.

The research group gathered 41 participants (20 in control and 21 in experimental) and conducted a hypothesis test based on this sample size. The Mann-Whitney U test gave the research group a p-value of 0.394, which means we failed to reject the null hypothesis. Thus, there is no significant difference in player's perceived wayfinding between the sector and nuclei layout.

Despite nuclei layout being smaller than sector layout, the responses from nuclei participants do get more mentions of places like landmarks and districts more frequently of 112 in total and an average of 5.6 than sector layout where the responses mentioned a total of 90 places with an average of 4.2. The research group suspects this might be due to the extra edges and districts in the nuclei layout, which are elements from the Lynchian elements that help people navigate throughout an environment. If this is the case, then it would be interesting to see in future studies if the nuclei layout is better for constructing a mental map than the sector theory is.

Based on the data gathered, the two conditions seem to have neither a positive nor negative effect on the participants' wayfinding ability. However, some of the data does indicate that there might be some difference between the construction of the participant's mental map and the condition they were playing.

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1 Introduction

Many types of modern games provides the player with a big area to explore in, there the area should be understandable for the player, and should not be difficult for the player to navigate around in. It can be a challenge to design for wayfinding in a small game without risking the player ends up feeling lost, whereas it is an even bigger challenge to design bigger games that results in the player does not feel lost or in doubt which why they should go.

The premise of wayfinding design is to plan for people's behaviour in a natural setting and design for their ability to perceive, select and understand information when faced with dense and stimulus rich environments. level designers also have to design for their ability to understand spatial characteristics of settings and their movements and, design for their ability to develop decisions to reach destinations. The logic of the design approach is derived from the logic of wayfinding behaviour. Thus, wayfinding design is more about creating help signifiers that are easy for the users to understand, reducing the chance of user error. This can be done through architectural design and building layout to make wayfinding more efficient and buildings that are well articulated. Wayfinding criteria are not constraints but incentives for innovative design solutions.

1.1 Initial Problem Statement

The research group has created an initial problem statement:

> "How can architectural design principles be used to affect a player's wayfinding within a game?"

This report begins with an analysis based on topics mentioned in the initial problem statement, such as architectural design principles and wayfinding in games. From each topic, the initial problem statement will get finalised into a final problem statement to use for the methods for hypothesis testing. Then it is followed up by the design section to elaborate on how the research group came to design decisions based on the analysis section and will be used for the final prototype. Then it is followed by an implementation chapter that contains some interesting scripts the research group wrote for the development of the final prototype. This is followed by results from the hypothesis test, interview and player position map data. Then the results will be analysed in the discussion, highlight potential flaws and improvements for future research, and end the report with a conclusion.

The goal of this study is to explore different wayfinding techniques and urban ecological zoning models with the purpose and the goal of this study is to find out if zoning layouts specifically multiple nuclei and sector theory have an affect on people's wayfinding ability.

2 Analysis

This section will explore how the five Lynchian elements which help people understand and navigate an environment. Followed by wayfinding techniques in real life and their relation to human senses. After that different types of urban structures will be explored and different types of museum spatial designs. Then the study will explore different types of spatial structure in games and lastly wayfinding in games will be explored.

2.1 The five Lynchian elements

Lynch created the five Lynchian architectural elements are seen as being good wayfinding techniques and can help people construct a mental map of the environment [1] [58] [46]. The five elements are paths, edges, districts, nodes, and landmarks/points of interest.
Paths direct the movement, similar to what negative space was used for in figure-ground and form theory which was mentioned in section 2.5. Paths can be roads, railroads, sidewalks, streets etc. [58] [1]. see figure 1.

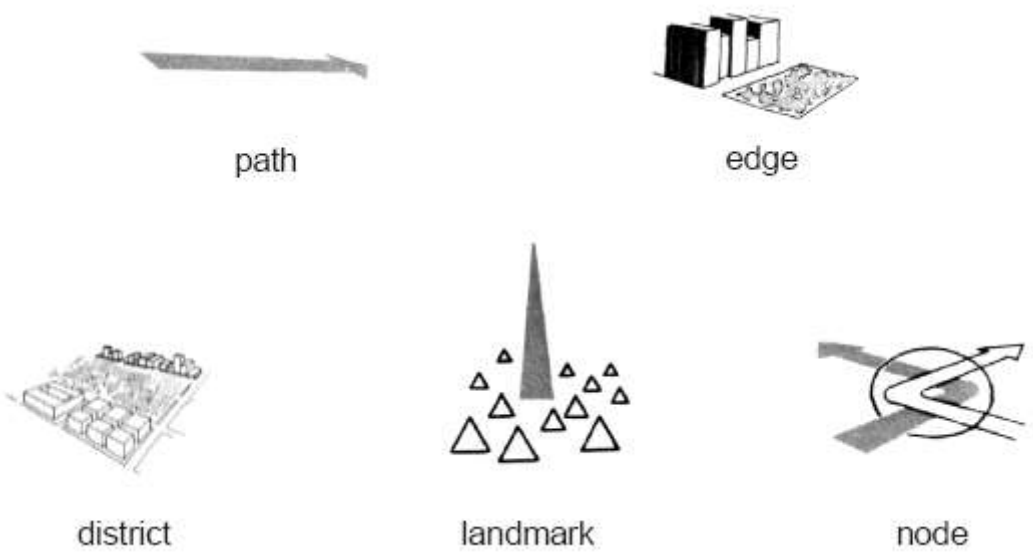


Figure 1: The five Lynchian elements [46]. Each elements like paths, edges, districts, landmarks and nodes can help people construct a mental from the environment [46].

Paths have three characteristics identity, continuity and directional quality [1]. A path's identity can derive from the nearby buildings and their facades, which indicate the significants of the path. Strong indicators for the start and end of paths also improve its identity, along with plants or texture of the sidewalk and pavement [1].Continuity of the path can come from the type of activities along the path and the path and the neighbouring paths' names [1]. The last characteristic directional quality is about consistent, and gradually changes in the surroundings, as well as a clear hierarchy along the road also improves the directional quality [1]. These could be indicators of the start, end or middle, and indicators of the path's origin and end. Abdelraheem does mention that if a path cross more than four different angle points, it can result in difficulty in orientation, three points can do this as well, but it happens more typically with four points [1]. Thus, it is recommended that paths should bend with a perpendicular angle of an intersection to lessen potential location difficulties [1].

Edges are boundaries of linear nature. They mark a transition to another area and are not formed by the path itself. The areas are distinct from each other; edges can be rivers, walls, a new type of texture, or a new theme of the environment [1] [58].

Districts are areas where its content shares characteristics and themes, meaning a visual identity of the area [1] [58]. There are also two different kinds of districts, external and internal [1]. External districts refer to districts that are interconnected with other districts, and internal districts are

districts that stand alone in their zone; thus, there is no link between the different districts [1].

Nodes can be seen as "strategic decision points" [58] placed at intersections or junctions where people clearly choose which path they are going to take [1] [58]. They can also appear to be used as gathering spots depending on the area [58] [1]. It is important that nodes have their own identity so that they are easily recognizable; it should be mentioned that a major element where nodes and landmarks differ. Landmarks will be explored later is that people can enter a node, and a landmark is an external point people can use as a reference point [1].

The last Lynchian elements are probably also the most well-known as landmarks/ Architectural Weenies/ points of interest, which also will be mentioned later in section 2.6.3[58] [1]. Landmarks are usually static and distinctive objects depending on their surroundings and space. Thus landmarks can be used for guiding posts for people who can see the landmark [1] [58]. Furthermore, a landmark can be dependent on other than the height of a building; it can have a subjective, cultural or historical meaning which makes it meaningful, recognizable, contrasting colour to neighbouring buildings, or attention-grabbing for people [1] [58]. In addition, landmarks can help people orient themselves in relation to it and the space, thus making a focal point for the route a person is taking.

2.1.1 Sub conclusion

This section explored the five Lycian elements which can help people create a mental map of a city or environment. Paths show direct movement between different areas. Edges show where an area ends or starts. Districts show areas with a common identity. Nodes can be used as decision points where the person decides why they want to continue or help them get back to the decision point; therefore, they should have some identity. Finally, landmarks were touched upon again, and they can be used as great focal points or orientation points. However, they can also be subjective, meaning that an object that might not have been different enough from a significant landmark can get a subjective meaning to people, thus making it a subjective landmark.

2.2 Wayfinding techniques in Human senses

This section will explore how people generate a metal map that helps them navigate around the world. Followed by how people's attention can be a draw to help them navigate a spatial layout, and how people use different types of attention techniques they use in different tasks.

2.2.1 Mental map and spatial knowledge

According to Lynch, there are five elements can result in a good performance in a city, the element "sense" of a city relates to how people recognize and organize the city's structure, i.e. sense is how people perceive space and the environment, and this has an effect on peoples wayfinding ability [1] Sense consists of formal and informal components each of these components further consists of three subcomponents, the formal components consist of:

- Identity is the spatial attributes and character of a place/object this can help identify an environment and the elements that make it unique, both from its owner's attributes and a person's own experience related to the place/object thus an identity event, that helps people remember the place/object [1].
- Structure is the object's spatial position to the person and other objects and its position within the object environment [1].
- Meaning is about what the place or object stands for, it can be both emotional and practical, a door for instance has the meaning to enter or exit [1].

The formal componets identity and structure, help people "perceive and organize both of space and time"[1] of the objects/place, while the meaning of the object/place help peoples associations of the object and place. The informal components consist of:

- Congruence is about form and function, does the size of the building match the function [1].
- Transparency means how many activities in the city a person can see in one position [1].

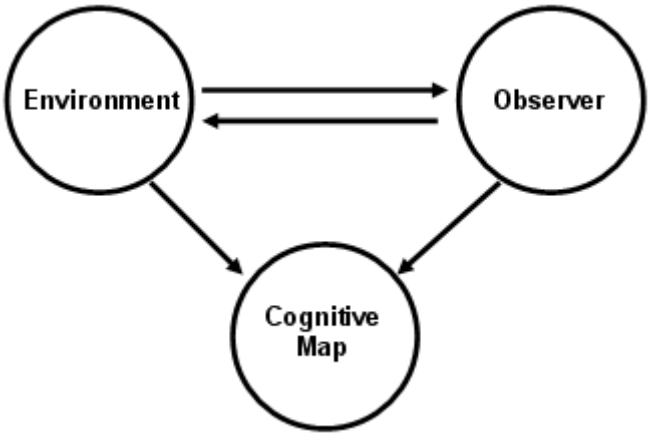


Figure 2: The figure shows the components of the observer and environment related to each other when the observer creates a mental map based on Abdelraheem research [1].

- Legibility refers to the ease people can organize different parts of the city into a cohesive pattern, thus the ease a person can create a mental map over the city for the function of wayfinding [1]. It contains the spatial attributes of the environments the "visual sensations of color, motion, smell, touch, and sound" these elements all affect on people's spatial cognition and representation [1]. In essence, legibility concerns how people can find a way through a given environment.

The informal elements create interaction between people and the environment[1].
Abdelraheem states that Lynch's theory regarding wayfinding depends on two things physical elements and how people draw the environment in their mind, this is what Lynch refers to as mental maps [1]. In figure 2 it can see how Lynch purpose how the environment and the observer each affect each other, thus affecting on the observer's mental map of the environment. The elements the environment bobble consisted of in figure 2 is differential with natural and man-made elements [1]. The quality of the visual elements results in people's better perception and mental map of the environment, thus resulting in better wayfinding for the people in the environment. These attributes are what Lynch has named for "Imageability"[1].
Imageability consists of two elements physical and cultural. The physical elements include attributes such as location, spatial relationship, " appearance (shape, color, age, size, construction materials...etc.)" [1]. The cultural elements consist of two components meaning and association, meaning includes elements such as " economical, political, social, historical, religious, functional " [1]. Association includes "familiarity, atmosphere and affinity" [1].
These elements suggests to be what people find attractive and vibrant, thus are important for people to create a mental representation of what the city contains which consequently are used by people to create a mental map [1].
When people construct a mental map, it includes elements of what the city contains these elements are what mental representations consist of, along with the actual environment. Many of these unique elements that help people create a mental map of a city, which consequently also help wayfinding in a city are known as Lynchian elements, these elements will be explored later in this section 2.1.

2.2.2 Attraction

According to Bitgood who is the author of the book "An Attention-Value Model of Museum Visitors", when people are visually exploring a scene or space for information, all of the stimuli in the environment are competing for our attention [7]. Therefore, each object within that space has the potential to pull focus away from the scene's intended focal point. To create effective and pulling wayfinding cues and ensure that important stimuli are the scene's focus, several strategies can increase an object's attention grabbing potential. Objects of utmost importance should trigger the person's orienting response, have landmark qualities, or be of high perceived value [7].
Humans' "orienting reflex" or "orienting response"[7] is a natural response to unanticipated environmental stimuli. This response is manifested as unexpected movements or noises, and these powerful stimuli causes the explorer to drop their current search, and immediately turn to face the stimulus's origin [7][6]. This type of reaction could be utilized within a game scenario to grab and focus the

player's attention on important landmarks and environment features.

When using a sudden, unexpected stimulus to grab the player's attention is not environmentally appropriate, games can use highly salience objects to grab the explorer's attention. High salience is associated with an object's contrast to its surroundings. For example, these objects could be a contrast in size, colour, shape, isolation from other objects, feature movement, or "multi-sensory stimulation". Bitgood has referred to these distinguishing features as "landmark qualities" [7][6]. Though games can create highly enticing focal points, their location in the scene is vital to ensure that the player can see and investigate this point. Unsurprisingly, objects within an explorer's line of sight have a higher probability of grabbing their attention [7][57]. Though distant high contrast stimuli may be visually enticing, players may not give these visual stimuli a high priority on their exploration checklist. The player's relative distance to an interesting stimulus is a highly important factor in determining its relevance to the player's exploration and attention. However, the player will ultimately reach this distant stimulus after attending to all nearby stimuli.

By controlling the structure of the environment and the location of its assets, the developer can influence the players' investigating priorities. To be effective at physically pulling in the viewer, the stimulus must hold the viewer's attention while the viewer inhibits their attention for other environment features [7]. A stimulus's value is derived from its pertinence to the current goal, and the potential benefits/costs of attending to the stimulus. Stimuli within the environment that are perceived as objects of a low-cost, high-benefit ratio, will be more likely to capture attention than items of low-benefit, high-cost. The item that offers the greatest benefit, for the least amount of time or work invested, is highly valued [6]. A small treasure chest located behind difficult enemies is likely to have a low perceived value by the player.

2.2.3 Top-down vs Bottom-up process to Attention

Modern game quests often revolve around seeking out and retrieving important plot devices [15]. When exploring an environment, attempting to locate a stimulus, the player will engage in one of several patterns of searching: "naive, primed, or exploration" [15].

- "Naive search are any searching task in which the navigator has no a prior knowledge of the whereabouts of the target in question. A naive search implies that an exhaustive search is to be performed" [15].
- Primed searches involve providing the explorer with information on what they are looking for, and where to look [15].
- "Exploration are any wayfinding tasks in which there is no target" [15].

Primed searchers are aware of their goal, and search the environment for features associated with that goal and is known to as the Top-down process [61]. These goals create bias in our perception, making searching for items within a game space that we are familiar with much more efficient [27][63]. These concepts are important to wayfinding because they enable the manipulation of an explorer's attention.

The bottom-up approach is when our brain interprets an event as something important, our attention is captured and directed toward the source of the stimulus (perhaps through the orienting response). Our brains decide that these stimuli need immediate attention, prioritising any pre-existing searches. [63]. Bitgood suggests that features of the environment that override the searcher's attention are creating "stimulus-driven attention". These stimuli prevent the viewer from conducting an extensive, calculated search of their environment [6]. The following picture below illustrates the different steps between top-down and bottom-up (see figure 3):

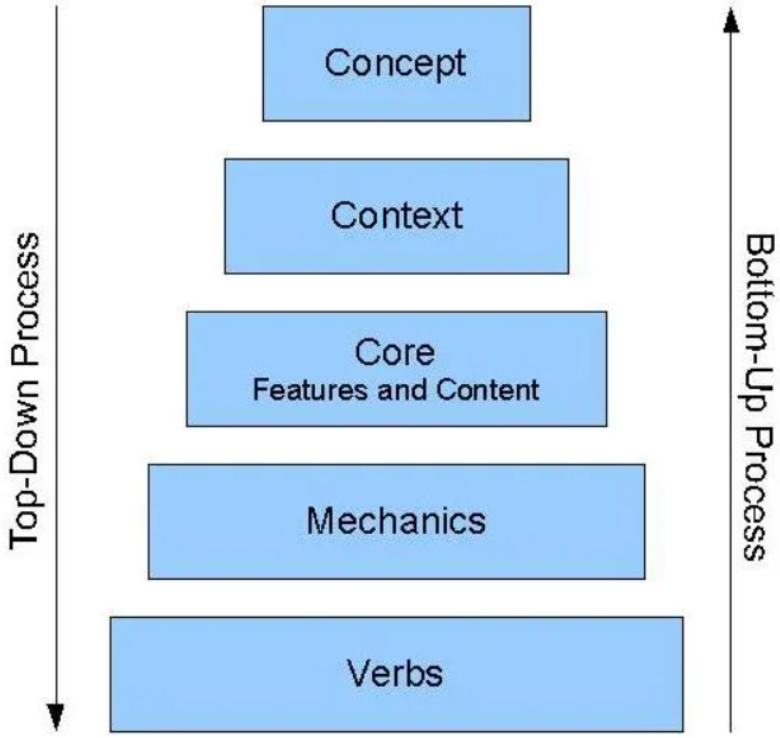


Figure 3: Example of the top-down vs bottom up processes when it comes to how different elements are processed by the user[34]

Bitgood suggests that there are two primary patterns for searching an environment: sequential and simultaneous [6]. Sequential searches move from one stimulus to the next, until the explorer finds something worthy of their attention. Simultaneous searches involve scanning the whole environment for an object that contrasts with the surroundings. When the viewer finds an interesting stimulus in either search type, they will stop investigating the point of interest. Games can harness sequential search patterns by stringing together focal points or landmarks slowly but effectively guiding the player through the level [6]. Kopec's "attention restoration theory" suggests that instances of extensive top-down, goal-driven attention, require high amounts of mental concentration [32]. Our directed attention can fatigue over time, reducing our capacity for concentration. Concentration and attention can be established through periods of "effortless attention" or "involuntary interest-based attention'[32]. It can be created in areas where there are no hazards and little effort is required for navigation, such as an enclosed corridor [32].

Video games frequently feature content that requires top-down, attention-heavy searching processing for players. Attentional fatigue can be combatted by punctuating intense visual searches with sections of effortless attention [32]. Developers can use the level structure and the environment to reduce the wayfinding attention required from the player. Natural environmental features are also highly effective at restoring directed attention in the player's attention. These strategies may be implemented to restore the player's attention after extensive periods of intensive attentional focus after intense searches. The amount of environmental stimuli present must be carefully balanced, as a lack of visual stimuli can also lead to issues. Environments that do not provide sufficient visual stimuli, failing to maintain explorer attention, can cause disinterest and anxiety [32]. Developers may use in-level visual cues to supplement the wayfinding information presented in the UI. These cues gives the players the option to use the environment or the UI to navigate. If the environment is providing excessive visual stimuli to the player, they can redirect their wayfinding attention to the UI [32].

2.2.4 Sub conclusion

This section has explored how people recognize and organizes the structure of a city through the element Lynch calls for sense, which will help people to draw an metal map over the city or envi-

ronment. Important elements of sense need to convey to a person are identifiable indicators of an object, the position of the object in regards to its neighbors, its meaning, that it gives congruence and transparency to the person and lastly how easy it is for people to create a cohesive pattern of the objects in relationship to the city. Imageability was also explored. Its effects also help create a mental map here; the location and spatial relationship, appearance, and cultural meaning are essential.

The effect of attractors has also been explored, and its uses for wayfinding and different types of attention capture attractors can be used. Thus, through the attractor design, they can guide the player through a spatial layout.
Three different types of searches people do when they navigate around in an environment have also been identified; Naive search, where people are not aware of where the object is they are searching for. Primed search is where people know what and where the object they are searching for is. Lastly, exploration is where people do not have any fixed goal for where they are going.

Two types of attention processes have also been explored. First, Top-down is where the person is aware of their goal and can then block out/filter out information they do not find relevant for their task. The bottom-up approach is when the person is susceptible to new attractors of new information, making that new goal for the search. However, it is essential to allow the players to switch between these two attention processes since mainly using the top-down approach can be draining for people.

Objects that give sense or imageability can also be used as attractors since they help the person metal map the environment. Attractors can also be placed as additional objects to help the people guide them through a specific section. Furthermore, attractors can help guide the person's attention process by using attractors to supply the person with effortless attention and attractors requiring a high amount of mental concentration. These elements that have been explored can be used to better people's wayfinding ability in cities or environments and should complement different types of spatial layouts.

2.3 Urban spatial structure

Urban planning today focuses on financial dimensions, land use, and transportation. Urban planning affects the inhabitants' sociology [10]. Both urban planners and urban sociologists agree that the geometrical shape and its zoning have an effect on the social life in the cities [10]. Before describing different types of urban planning and zonings and the effects. First, the fundamental purpose of a city and the city's role needs to be described Knox describe the fundamental roles of a city within three categories [29] within a capitalistic economy which are: Mobilization is the efficient and effective area "for organizing labour, capital,... and for distributing finished products" [29] in short, it creates an "industrial atmosphere" which benefits the economy.

The decision-making capacity of urban settings is that a city becomes a point of both public and private power, which stems from companies and organizations, resulting in both "political and economic power"[29]. A generative function is a natural consequence of having a high concentration of people in the same general area, creating more "interaction and competition"[29], also known as "creative fields". Creative fields "fostering innovation, generating knowledge,and disseminating information" [29].

Based on the three roles a city has within a capitalistic economy according to Knox it can be seen that cities are in general concentrated areas where economics can grow, a mix of power, and generally where innovation develops. The latter can also be seen through different types of capital innovations (economic, social and cultural capital)[29].
With the roles of cities defined the ecological models and the zoning /spatial geometry /urban land/site planning can be explored[29][10][52]. Three major models have been observed, that can explain cities' spatial geometrical development from the 20th century [52]. These models are somewhat distinct but have been observed and proven by scholars in the field [52]. Even though the three models are distinct from each other, they are all based on seven shared assumptions. Which are described below:

1. The "city is growing in population and expanding in economic activities"[52]

2. A "relatively free land market that is responsive to the economic principles of supply and demand with little in the way of government regulation" [52]

3. "An economic base that is mainly a mix of industrial commercial activities" [52]

4. "Private ownership of property"[52]

5. "Specialization in land use"[52]

6. A "transportation system that is fairly rapid and efficient, and generally available in terms of cost to the majority of the population"[52]

7. "Freedom of residential choice, at least for the higher socioeconomic strata"[52]

These assumptions does fit into what Knox defined as the roles a city has within a capitalist economy (assumption 4). Assumption 6 does fit within the Knox's mobilization role in the organization of labour and capital where a sound transportation system is good for the organization of labour for both the transportation of the workforce and product distribution.

The assumptions with assumptions 2, 3, 5 and 7 does fit into the role of decision-making capacity though these three assumptions do point to a power imbalance where the economic power is greater than the political power. The seven assumptions do not directly point to the role of the generative function, but competition between companies is also a reality within a capitalistic economy. Thus, these assumptions do work well within the roles of a city.

With the fundamental assumptions described, the three most dominating zonings based on urban growth from industrial cities can be explored; in figure 4 the three different zoning types can be seen.

The concentric zone model (top left on figure 4), this type of design is based on a city where rapid growth of population and economy occurs. The model is based around the central business district (CBD), where each new ring represents different types of groups within the social and economic status hierarchy [52]. The second area surrounding the model's core is the socially stigmatized groups where slums are also allocated, followed by the blue colour working class, the middle class and lastly, the upper class. This model differs from the next model that will be described in that if a person is travelling from the CBD out of the city, the person will see the different status compositions the city has to offer. The model is also known as the Chicago model, as Chicago was used as a prototype for a growing industrial city in the USA [52].

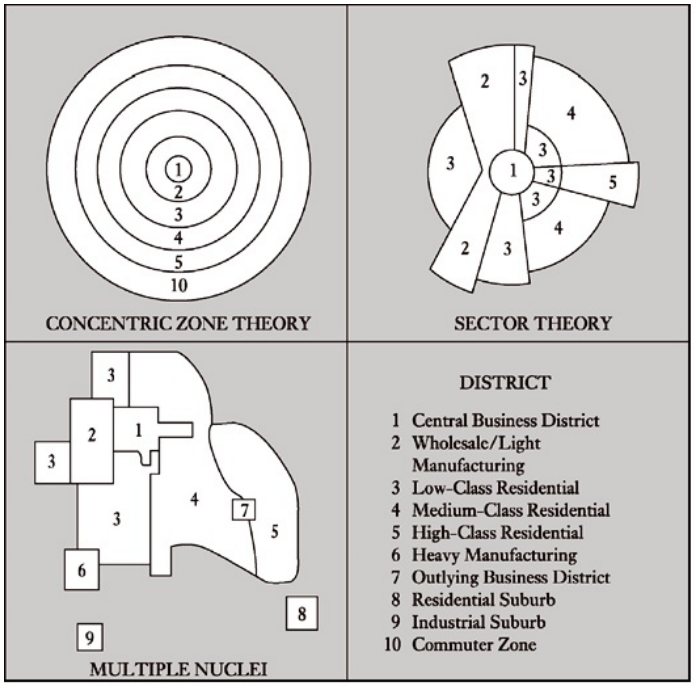


Figure 4: This figure illustrates the three ecological layouts for urban form [52]

The sector model (top right on figure 4), this type of model is also designed around the CBD and is based on the that urban growth develops along where transportation toward the city centre is placed; this could be railroads or main routes. This type of design organizes the different socio-economic groups homogeneous throughout the city, so if a person travels from the CBD to the edge of the city, the person would only experience one type of status composition the city has [52].
World of Warcraft (WoW) also has used the sector layout in their game. However, they use the sector zoning a bit different than what is shown in fig 4, WoW uses the sector layout as a difficulty region that supports a linear progression based on the player's level as can be seen in figure 5. Based on this figure, the player can see which regions they are high enough level to enter and supports a linear homogeneous progression within the different regions.

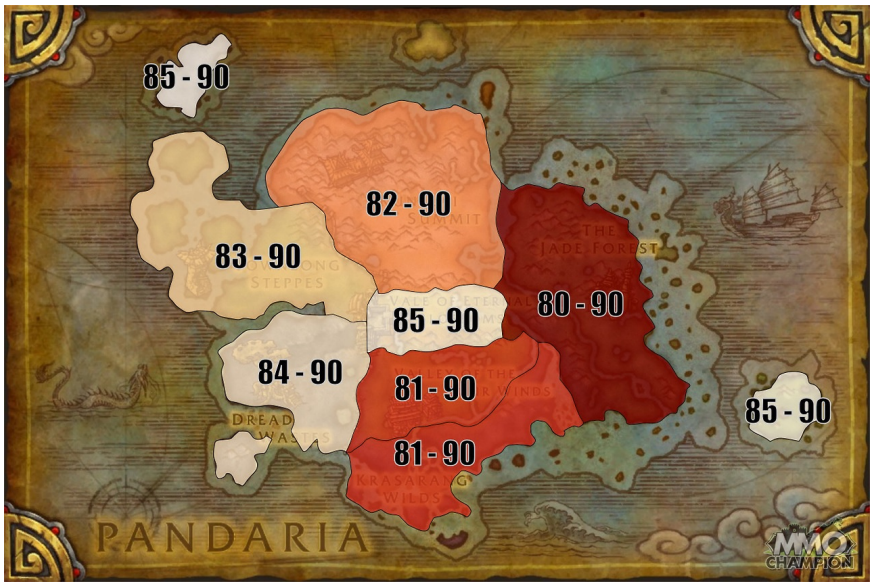


Figure 5: This figure illustrates how the layout for Pandaria in World of Warcraft resembles Sector layout[18]

Multiple Nuclei model is the last model (lower right on figure 4); the model differs from the two models mentioned earlier since, in this model, the zoning is not based around the CBD [52]. Instead, the model is separated into different nuclei where each of them affects the spatial layout and effect the social life within and between the different nuclei; thus, this model ends up looking like patchwork or a more modular designed layout [52]. Furthermore, the different nuclei can have different sizes depending on the purpose for it; a small nucleus could, for instance, be an area where a strip mall is located, and a prominent nucleus could be a manufacturing district [52]. There are four patterns in regards to where certain districts are located within the model those are:

- Some nuclei require large areas of land like manufacturing areas [52].
- Profit activities where the profit is gained from products produced outside of the district are seen in clusters shops or shopping centers [52].
- Some activities between the nuclei are damaging to each other and cannot be placed next to each other, such nuclei could be manufacturing districts and upper-class housing [52].
- Some activities for some people are unable to participate in other activities in other districts due to the cost [52]. For instance, people from low-income areas are not able to part take in activities in high-income areas [52].

These four patterns or different types of relationships can create zoning that will help people's mental model of where they are in the city.
multiple nuclei have mainly been observed in developed countries [52]. However, in open area games such as Divinity original sin 2 [55], they design their levels/areas based on level zoning, meaning that the player can move without being under or over-levelled with the enemies in those areas. Their level zoning does also look similar to the multiple nuclei model. The level map can be seen on figure 6.

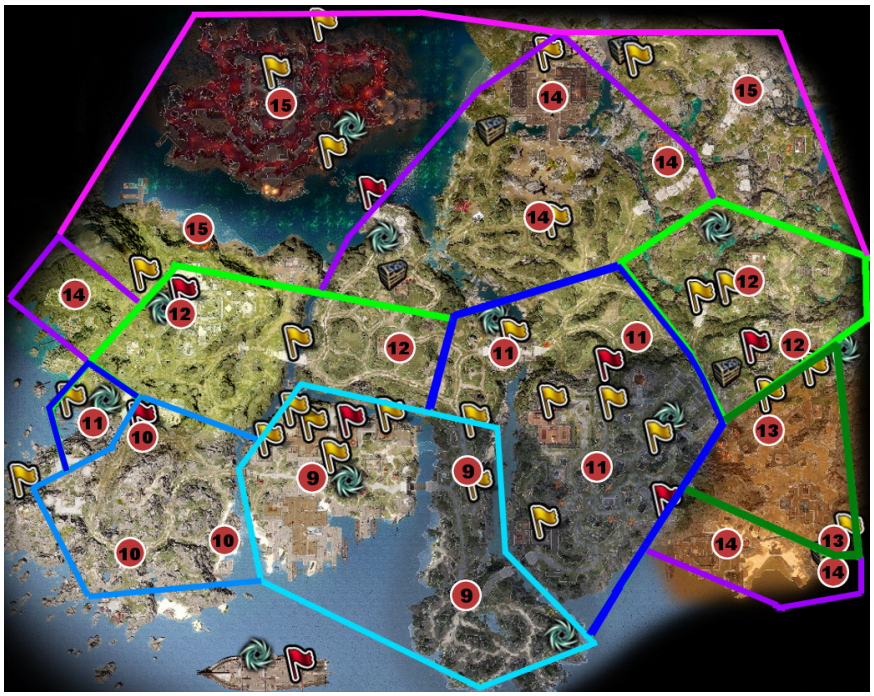


Figure 6: This figure shows the level zonings for the enemies in Divinity Original Sin 2. The map is of act 2 of the game. This figure is from the forum Quarter To Three Forum [24] and lines create with paint dot net[24].

2.3.1 Sub conclusion

This section has explored the role of a city and how urban growth affects the city's spatial layout. It has been defined how the role of a city and these three ecological models match each other. Another benefit of these models is that they give a clear indicator of what each section of the city should include and might reduce confusion or create predictability for the people visiting/travelling in the city. While these models explain the spatial layouts of cities that have grown during the 20th century, their pattern could be a good baseline for level design in games. Similar to how WoW's layout shows the players the minimum level the player should be in for each region. Alternatively, how Divinity original sin 2 had designed its areas and how their layout can be used to guide the player around an open area linearly but without forcing the player to take a specific path.

2.4 Museum Spatial Design

Museums require reasonable and understandable layouts for visitors to not feel lost. In the United States, museums' cost is around 21 billion USD [25], so an excellent spatial layout for the visitors should also be considered to ensure the visitors feel comfortable when visiting them. This section will explore some of these spatial layouts museums uses.

When designing museum exhibits, architects have to engage and make visitors comfortable. No matter the theme, the architects and curators have to collaborate to surpass visitors' expectations whilst sparking their curiosity and being disruptive [47]. Disruption can be seen as a positive aspect as it challenges perfection and looks for improvements to the overall thought process.
For planning and designing spaces for visitors to go through, one can use mind maps, concept diagrams, bubble diagrams, sketches, models, and scale drawings as visual tools for object placements [47]. When designing and developing spaces for visitors, the size and scope of the space have to be considered, along with spatial planning (utilizing all the space) and visitors flow/pace [47]. When it comes to planning the visitor's pathing, there are several methods to navigate the visitors through a design space, and are as follows:

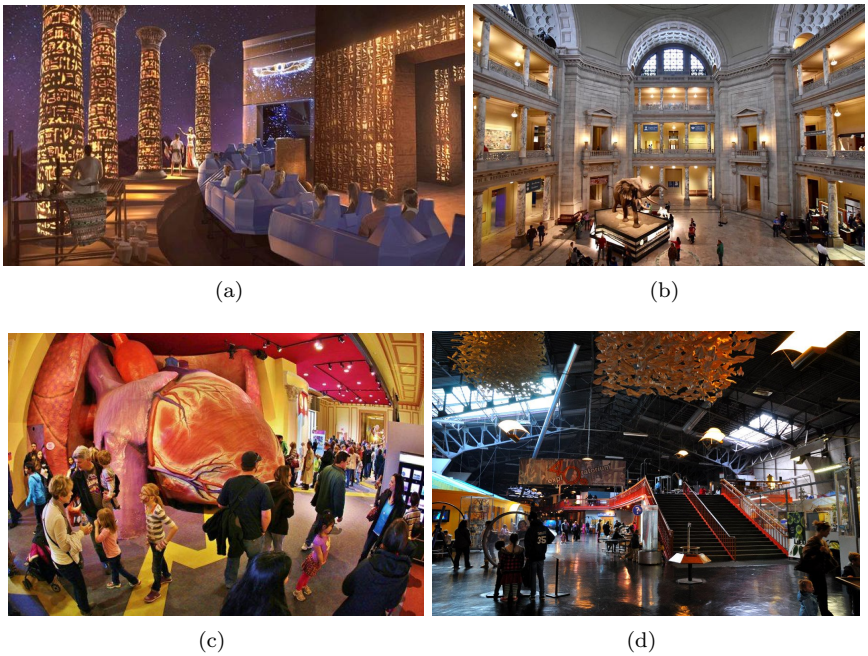
1. The forced march, directed plan or linear - forces visitors down a linear route where there are limited choices of accessibility to various contents [47].

2. The central core or radial plan - the central hub of the main attraction, meeting place or focal point where other areas are adjacent to the main attraction which visitors can go and return

to the same point where they started without too much hassle [47].

3. The pinball or random plan - can lead to multiple routes and give visitors options of where to go. The paths which visitors can choose can be staggered fashion, backtracking or overlapping paths and therefore lead to pathways, though linked physically, are not sequential (non-linear) [47].

4. The survey or open plan - unobstructed views of nearly all exhibition content within the space and allows visitors a free choice of paths. It gives visitors the freedom to orient to the open space, decide their pathways and estimate how much time it would take [47].



(a) (b)

(c) (d)

Figure 7: Different exhibitions using different pathing plans: Spaceship Earth with forced march plan (a), The National Museum of Natural History with central core plan (b), The KidScience exhibition at the Franklin Institute Science Museum with Pinball plan (c), and the Exploratorium in San Francisco with survey plan (d) [47].

Each of these approaches has its merits, but it is recommended to mix and match the principles to create your own approach [47].

Space syntax analysis is used to determine how spaces are related to other spaces within a more extensive system, rather than through the more traditional characterization of metric distance [62] [45]. Syntactically a system of spaces is more integrated if spaces can be easily reached from one another or more segregated if one must travel through many other spaces to move from one space to another. The layout of the space is also affected by enunciation, transmission, and social organization of knowledge. Enunciation of the presentation of knowledge is related to the categorization or grouping of knowledge units and how they are physically connected (or separated) in space. The spatial layout also affects the socialization of knowledge, how rather than what visitors learn and orient them to what different spaces and layouts may be associated with each other, e.g. how a visitor can see that central core plan can have places associated to the same theme, thus knowing what to expect through each section, creating predictability for the visitors [62] [45].

2.4.1 Sub conclusion

Different types of museum layouts and how to analyze space syntax have been explored. Some of the layouts mentioned have also been seen in various video games (which will be explored later). Using the space syntax analysis is an excellent tool to figure the space in the prototype's level design. The same can be said for the other sketching tools mentioned, for instance, through bubble diagrams.

2.5 Spatial and structural design in games

Architecture in games differs from real-world architecture in several aspects; for instance, Zoning regulations and structural realities and requirements [58], A house in a game does not require both an interior and an exterior, nor its structural requirements.
This allows level designers to design spatial layouts to complement different game design elements such as "player movement patterns, narrative events, or game mechanics" [58]. This section will explore different types of spatial arrangements used in games and which type of effect it has.

The concept of figure-ground and form void stems from architecture; both of them are about the concept of the composition of positive and negative space [58]. Figure-ground is used in two dimensions, where the positive space represents different elements/structures, and the negative space represents the ground [58]. This concept can be used to create or draft different additive and subtracting space types. For example, gamespaces are often based around the player's movement through negative game spaces, and creating spaces between forms allows for the creation of rooms or other types of spaces that complement the game mechanics and objective [58].

Form void is the three-dimensional version of figure-ground which can be used for spatial arrangement by subtracting or adding mass to the game environment [58].
Arrivals refer to the designed experience built around the structural destination of where the player should go and how the design is visually communicated to the player. Here the contrast is often used; for instance, if the player is within a narrow place, the following area should be broad and open; this has the effect that the player perceives this as to be wider than the room is[58].

Another element from the concept is the player's field of view, from and to the arrival point of the player; here, the designer can block essential elements from the player until the reveal of the arrival point [58]. A Plague Tale: Innocence [54] has a good example where both of the mentioned elements are being used; the player is walking up through a hill, and big rocks on the left side of the screen aqueducts are blocking the other side of the screen when the player finally reaches to the top of the hill the camera turns so the player can see what the rocks have blocked and a gain field of dead soldiers and war machines can be seen, and the reveal makes the player think that the field is much bigger than it is, and surprise that all that destruction was just behind the hill and the rocks.

Many types of game spaces used in games have roots in historical structures/sites; these can be used to analyze the different level structures in the game: "linearly, branching, or interconnected." and hub space [58]. The functional effect of these four types was also mentioned in section 2.4 the forced march is linear, the pinball is interconnected, the survey can work as a branching structure, and lastly, the hub space can have the same layout as the central core.

The linear type structure is routed back to the Labyrinth, where the paths bend around each other and end in the centre [58]. This allows for different twists and challenges for the gameplay experience; the structure of a Labyrinth is generally good for narrative-focused games [58], and are mostly is mainly associated with Naughty dog games.

The branching type structure stems back to the maze, which are spatial structures that can lead to different directions, the branching nature of mazes awakens an exploratory curiosity and risk-reward feeling in the player [58]. Paths that lead away from the objective can potentially lead to a reward or a dangerous enemy to the player.

The term the interconnected type structure stems from botany and is called a rhizome, in is a network of roots that is created by "underground stems of plants"[58]. In this type of space, the player can travel from any one place to another; this has been parallel to how the internet works in regards to travel from one website to another and how fast travel systems works in sandbox spaces [58], which will be explored later.

Hub spaces are differentiated from the three previously mentioned spaces since this space can be used in combination with the other types of space, most commonly with linear type spaces [58]. Hub spaces are used to separate different game levels from the hub, where the player is allowed to select which levels they want to play. By using the central core as an example layout from section 2.4, the hub is the central core where the different acts or level theme is different depending on

which corridor the player chooses to walk through. In addition to this, the hub can be used as a safe place for the player and be used for the player to explore and train themselves with game mechanics without risk for the player [58]. The game A hat in time [9] uses this hub design to allow the player to use/train different types of game mechanics combinations and the different mechanics in a non-stressful environment. This gives the player a more open feel to the game by allowing the player to select the different levels they want to play or replay.

Sandbox spaces or open-world/area games are designed to give the player the feeling of an open world the player can play in, meaning that the player is given an unstructured way to play the game [58]. Many open-world games have problems that have the same problems as real-life cities can suffer from "orientation and location awareness."[58]. Thus many open-world games take place in a city, which then allows the level designer to use the same navigational techniques as urban designers use [58] see section 2.1. However, as mentioned earlier, virtual environments are not bound to the same requirements as the real world. Therefore, several different techniques can be used to help the player to orientate themselves and to help their location awareness which urban planners do not necessarily can apply when designing a city see section 2.2.

2.5.1 Sub conclusion

This section has explored how to plan the design of a level where the player movement has been taken into consideration using positive and negative space. These planning techniques seem like an efficient way to plan a design with movement taken into consideration, an effective second step after using the drafting tools that were explored in section 2.4 and can be used in relation to the three ecological models that was mentioned in section 2.3.
How to plan interesting introductions for the player through arrivals where the player's field of view and balancing the type of space the player is currently in and will enter. This technique might be helpful in the design process.
Different types of spatial structures in games have also been explored; some of them are also similar to some museum layouts in section 2.4. The design around an open area game can also have its overall baseline created around the other types of spaces mentioned earlier or the three models explored in section 2.3.

2.6 Wayfinding techniques in Games

The premise of wayfinding design in games is to plan for people's behavior in virtual setting, and developers can use this technique with these design approaches in mind:

- Design for their ability to perceive, select and understand information when faced with dense and stimulus rich environments.
- Design for their ability to understand spatial characteristics of settings and their movements through them.
- Design for their ability to develop decisions in order to reach destinations.

These design approaches is derived from the logic of wayfinding behavior. Wayfinding design is not about creating simple architecture, but about the design of architecturally interesting, wayfinding efficient techniques that are well articulated [58].

2.6.1 UI and HUD

User interface (UI) and Heads-up display (HUD) wayfinding systems can greatly vary in their uses within a game. According to Fullerton and Rogers, UI refers to the methods which a user interacts with a system or game with keyboard and mouse controls. In contrast, HUD refers to the method of displaying graphical information in a way that overlays normal vision through icons and pictures [19][49]. It may be unreasonable to guide the player through massive virtual environments with total reliance on visual cues in large open-world games. As a result, developers may decide that immersive wayfinding is not a vital game feature. Instead, in-game visual cues can be used to reduce the reliance on UI elements as the primary wayfinding method. By allocating wayfinding cues throughout the virtual environments, games can provide the player with ample navigational information,

reduce the presence of UIs and HUDs, and add layer of player participation to the game. Three of the most prominent UI and HUD wayfinding methods include floating points, manually engaged dynamic directions, and persistent dynamic directions.

Figure 8: Example UI from "Genshin Impact" using both mini map and floating point system [41].

The floating points wayfinding system uses persistent floating markers to indicate the direction of the player's goal as seen on figure 8. The markers do not account for obstacles between the player and their goal, but may indicate the direct distance to the objective. The manually engaged dynamic direction system is a non-persistent cue that must be engaged by the player. Upon the player's request, the game will generate a dynamic in-level or UI cue that will point towards the goal. These cues is often spawned as as arrow or line. This specific pathfinding technique and cues can remove player's involvement in wayfinding. The persistent dynamic direction system communicates wayfinding information through an ever-present dynamic visual cue. The cue will constantly update to show the most efficient path to the goal. This visual cue may be placed within the player's HUD, or located in the game world. The game will dynamically generate a glowing breadcrumb trail, with pathfinding, showing players which direction to travel.

Newman suggests that UI wayfinding mechanisms, like maps or compasses, can be used to reduce the cognitive load dedicated to wayfinding [43]. These maps or compasses allow players to focus their attention on other gameplay tasks. However, Madigan states that requiring active player navigation may increase their immersive experience, and creating cognitively demanding environments is one of the keys to creating an immersive experience [38]. Additionally, demanding mental resources within an activity is one of the components to experience flow [14]. Additionally, for a player to navigate minimal UI aid, environments must be well constructed and provide effective wayfinding cues. However, too many UI elements on the screen might also take the players attention away from design of the virtual environment.

2.6.2 Light

Humans are naturally drawn towards light, following the brightest path within a game should be a natural reaction; this make light as a navigational cue optimal [49] [53].
Strategic lighting is one of the more expansively covered in-game wayfinding cues, used to both guide the player, and communicate the contents of the environment. When deployed effectively, lighting is a highly effective wayfinding cue. In addition moving objects (see section 2.6.7) and sound (see section 2.6.8). The player motivation type "Achievers" and "Explorers" from Bartle writes that both of them heavily preferring lighting navigation cues [4]. Lighting permits developers to pique the interest of the player, create refuge from the dark, highlight specific landscapes and items, and provide greater visibility of the surrounding areas. Psychologist Joye suggests that illuminated

regions of an area will "draw attention and trigger explorative behaviour" in the explorer [28]. The following picture illustrates how two different games designs wayfinding using light in different ways (see figure 9)

(a) (b)

Figure 9: Example (a) is from Call of Duty: Black Ops 2, where you guide the player through a corridor using colors and light. Example (b) is from Bioshock Infinite where the developers use separate lights to emphasize the composition of the room and highlight specific objects [59] [20].

Key lighting and fill lighting Byrne makes the distinction between two different lighting types: "key lighting" and "fill lighting" [11]. Key lighting is the most important implementation of lighting for wayfinding. The level can communicate the exit/final destination of a region by ensuring that it is well lit with key lighting. This both highlights the exit location of the area, insuring visibility, and will influence the player to associate well-lit sections with progression [33]. Not all lighting within games serves as key lighting. The lighting used to illuminate the environment as a whole is referred to by Byrne as "fill lighting". This lighting allows the player to see their surroundings, while not necessarily highlighting important features [11]. Unless design decisions restrict lighting, environments should have sufficient fill lighting for the player to properly perceive their surroundings. However, if the developer uses a red emergency light as the key light, illuminating the exit or an important object, the player may be more willing to investigate, as it varies in brightness, colour, and origin. The contrast in an environment's lighting may also pique the player's curiosity. Covered at greater lengths below, contrast can be an effective and enticing visual feature. A brightly lit area at the end of a dark room will guide the player to that spot. Likewise, a shadowy corner of a well-lit room will almost always invite curiosity. . . " [11]. It is not the physical appearance of the dark sections that are visually appealing, but how they contrast with the surrounding environment.

Path highlighting Depending on the visual style of a game, it can be an effective wayfinding strategy to ensure that the primary path is the most well-lit, or only well-lit section of the environment. Jenssen suggests that this is an effective method for aiding wayfinding through complex environments [26]. This strategy is particularly effective due to humans' tendency to follow the brightest path available. In a study by Ginther found that basically people are like moths—attracted to brightness [22].

By priming the player to seek out lights (providing rewards for following key lighting), and harnessing their natural attraction to illumination, we can create effective cues for light-based navigation. Rogers states that Naughty Dog, developers of the Uncharted series and The Last of Us, use a "squint test" to ensure that the primary path is the brightest area on screen. If the player squints their eyes, the brightest areas on screen should be the main path [17]. Even if the players do not associate the well-lit sections with the main path, the main path's content will be well illuminated, allowing players to plan their movement [49].

2.6.3 Breadcrumbs and Landmarks

Breadcrumbs can take most forms as long as it is attention pulling, it is used to break up negative space, and they can be, for instance, pick-ups, lit areas or even enemies [53]. The purpose of breadcrumbs is to catch the explorer's attention and entice them to move in and investigate. As stated above, moving the explorer through the environment with sequential visual cues is the most effective

method for ensuring that each cue receives attention [6], and breadcrumbs are great enablers of this. This navigation strategy can be seen in numerous video games, museums, and theme parks like Disneyland [49],[6]. The difficulty of a game's navigation can be tuned by tweaking the breadcrumbs' number, frequency, distribution, and strength. "The bigger and more numerous the bread crumbs, the easier it is for the player to find his way through the woods" [5]. The more directed the player, the lower the navigational difficulty.

Figure 10: Example of a Landmark from Half-Life 2 where the player will know where the end goal is in the game [13].

Landmarks are a variety of breadcrumb that are commonly used in games. They are objects, or bundles of objects, which act as compelling destination points, beautification features, and objects of orientation [58]. They often take the form of "fountains, statues, distinct buildings, and large machines...", and are frequently the focal point of their environment [12]. A landmark can appear in any state, but it has to be unique. The uniqueness of its appearance and its size relative to its surroundings are what lend the landmark memorability and recognition. This ease of recognition makes landmarks effective points of reference and orientation for players [5], which aids the process of cognitive mapping [43]. In figure 10 gives a good example of a landmark within a game.

Cognitive maps, or mental maps, are mental representations or drawing of an environment's spatial layout [12]. As the area's focal point, landmarks help visually complete the scene, reduce the wayfinder's anxiety, and provide a final destination to focus on. Landmarks presented at a distance, but still in the player's line of sight, will coax the player to explore the environment and find a path to this object [42]. As distant landmarks are often seen as an ultimate destination and the focal point of a region, it should be "distinct from its surroundings", contrasting its immediate environment and feature "landmark qualities" [15] [6].

Landmark qualities are object features that increase its salience to an explorer, such as: contrasting colour, shape, or movement [7]. This contrast in appearance with its surroundings will make the landmark more visually interesting, and more likely to pull the player in. They do not have to be incongruous cues, and their existence and appearance can still be grounded in the game's world.
To make landmarks a more effective and pulling wayfinding cue, Bates suggests that it is proper practice to supply players with a reward for reaching the landmark destination [5]. By rewarding the player, the game is creating a positive association between the landmark, and treasure/rewards. This is an effective tool for priming the players to seek out certain features of the environment, see section 2.1 for how landmarks is used in the real world.

2.6.4 Physical barriers and choke points

Prior to the development of any game environments, the design team will decide on an overall environmental structure that will best support their gameplay. The majority of games which use a first or third-person viewpoint, will employ a linear environment, an open environment, or a combination

of the two. Rogers refers to linear and open environments as alleys and islands, respectively. Linear and open environments can have radically different approaches to level and wayfinding design[49].

As open environments often have a much freer approach to quests and wayfinding, they will not be discussed in this section. Linear games often feature a single path, larger areas, or branching paths that terminate at a single area of advancement. This ensures that all players will advance through the environments in a certain order, and guarantees that players must pass through progression points to advance the game. This is an important feature that is unique to linear games, as it allows the development of game sections that all players will see. Designers can inject important plot points, items, visuals, or other content, into these chokepoints, ensuring that all players who advance past this point will be exposed to the same important information.

Barriers can also be used to block the player from revisiting content that they have already experienced. This would be an example of Kremer's push mechanic [33]. By blocking off sections of the environment, the game can help refocus the player on the path forward and reduce wayfinding confusion from the available backtracking options.
Shaver differentiate between two types of choke points which he calls for gates and valves, where gates only prevent backtracking until a condition has been made for instance if the player jumps down a hole, but at the bottom of the hole the player will learn how to climb on the wall the player can then backtrack [53]. Valves however just prevent backtrack for the reason mentioned earlier[53]. The barriers used for choke points can be various, locked doors high walls or a high level, or a number of enemies. when using chokepoints such as gates the designer should take into consideration that the player is no longer able to backtrack to find collectibles or other types of experiences they may have missed.

By providing additional spaces outside of the main path, linear games can create a more believable environment. " Fingers", as described by Rogers, are dead ends that extend off from the main game path, terminating before feeding back into the path forward. This provides players with additional areas of exploration, while still ensuring that players must advance down the primary path [49]. However, adding too many fingers or secondary areas to the main path may be confusing. Despite how linear the level may be, every stream that breaks off from the main path will increase the chances that the player will get lost. One of the most effective methods for pushing the player to a single destination is through the use of chokepoints.

2.6.5 Colour

Colour cues can be successful as a wayfinding tactic, restricting the use of a particular colour for the purpose of wayfinding can have a major impact on the aesthetic style of a game [39].

Use of colour in-games can also be inspired by real-life visual cues. By harnessing our pre-existing knowledge of colours and wayfinding in the real world, games can implement visual cues that will immediately communicate the state of an area. Green and red colour cues are often used in games to communicate the accessibility of an area or doorway. This trend is continued in later games in the series, featuring a similar colour scheme: green: freely accessible, amber: door can be opened through hacking or "bypassing", red: currently inaccessible and likely will be unlocked by completing mission requirements [39]. Colour, while used extensively in all parts of game design, can also be a key to wayfinding. Colour is an important tool for drawing the attention of the player to a certain area or object within an environment. Kopacz suggests that we can create "focus" within scenes by applying colour to emphasize important features. Objects that are composed of the brightest colours within a scene, or are of high contrast, will often draw the viewer's attention. However, the more frequently a colour is used, the lesser its ability to pull attention [31].

Mirror's Edge uses bright, obvious red colour cues within the environment to indicate the most efficient, or only route forward [16]. As the players are traversing environments with haste, the red colour used is high in saturation, and is restricted to wayfinding objects. But this colour serves two purposes: it highlights which direction the player must go, and the object required to go that direction; for example, if the player must jump across a large gap between rooftops, a small ramp at the edge of the roof will be highlighted red. This will show the player that they must use this ramp to get across the gap. Thus, the player knows which direction to go, and how to get there. In this game world, the items for navigation have been coloured red purely for the sake of wayfinding. In a

room filled with white pipes, a singular red pipe will indicate the path forwards. It is clear to the players that these object exist in a coloured state, not due to natural appearance, but because the developer needs to help the player with wayfinding. While this may result in some inconsistencies in the game's aesthetics, the player needs to move through the environment quickly, and the level needs to relay obvious cues to the player.

Figure 11: Example Mirror's Edge where the platforms and rope are highlighted red to give the player a cue that they can interact with these objects [16]

Through continual exposure to these colour cues within levels, the players will begin to recognize their purpose as the wayfinding infrastructure. When players have noticed that a colour cue indicates the path forward, they will become sensitive to this colour, making it easier to spot within scenes, and easier to filter out non-essential information when conducting a search [39]. This will help the player notice both the path forward, and important items [39]. The Last of Us relies on in-game colour cues that are not only more subtle, but also make sense in the world [17]. Caution tape, ladders, bridges, paint streaks, and signs, all could reasonably be coloured yellow, while still appearing to naturally fit their surroundings. The developer does not colour non-yellow objects simply for the sake of game wayfinding; for example, the player will not see a stop sign or tree trunk that have been coloured yellow to mark the path forwards. that mark the path forward through natural cues. This is a direct contrast to Mirror's Edge, where objects will be inconsistently coloured within the same level to communicate the wayfinding information.

Figure 12: Example from Last of Us where the color of the bridge is slightly more intense and more out of place than anything else in the scene [17]

Closed doors will take on a green glow if legally operable, or a red glow if inoperable. Other games, such as Fable II, present some doors' accessibility by presenting the doors with an ambient glow of colour [56]. This colour glow, while effective at communicating the status of the door, is clearly direct communication from the developer to the player. The doors are glowing because the developer needs to communicate the door's accessibility, not because the doors would naturally glow within this world [39].

If game immersion is an important consideration for a title, designers need to ensure that visual features within the environments must conform to the internal logic of the game. While glowing doors could certainly exist in the world of Fable, as magic exists, the game does not establish that doors are magically enchanted in any way [56]. These colour cues become features that are incongruous to the fantasy setting that has been established in the game world that is not consistent with the 'game's internal logic" [39].

2.6.6 High ground

High ground is another level design strategy that is supported by documentation outside of game design. As the effectiveness of light was discussed previously, we cannot assume that high ground is effective in itself. One of the main supporting theories for this idea is Appleton's prospect-refuge theory [3]. This inherent trait may influence the pleasure that humans experience with landscape art, which often emulates a high position overlooking the surrounding area [40]. Creating a physical space that offers the player a view of the surrounding landscape could potentially influence the direction that they travel.

If players tend to seek out high ground in a game, developers can take advantage of this by including elevated points that give views of important content, or by terminating a level atop a peak [40]. By providing points of ascent in consistently flat or declining areas, players may be enticed to climb these points. Interesting objects could be located atop these elevated points or, the elevated points may simply provide a valuable view of the surrounding landscape and nearby landmarks. Higher ground both influences the player to climb it, and also sets up additional visual cues and landmarks, influencing where the player will travel next [40].

Humans' tendency to seek out higher ground grants a greater understanding of the immediate, and distant surroundings [28]. This aids in establishing a mental model of the world. As stated above, the production of a mental model is an important aspect of experiencing spatial presence within a digital environment. By providing an elevated point within a game level, games are providing level progression that is innately preferred, enabling the creation of mental models, and providing an overview of the immediate area [40].

2.6.7 Motion

Nisbet and Shaver suggests that the use of moving objects and motion within levels can be an effective strategy for catching the eye of players and guiding them in a certain direction [44] [53]. This strategy is effective for those who fall under the Achievers, Killers, and Explorers categories of Bartle's gamer psychology classifications [4]. If a level designer wants the user to explore an area on their own time, then it would be wise to avoid the use of strong, orienting response-inducing stimuli. If an orienting response is induced within a player, the player may never return to the stimuli that they were originally investigating. This is an example of "inhibition of return", causing the player to drop their previous activity and pursue this new, powerful stimulus [6]. This effect can happen to the player when induced with a strong motion or sound stimuli [6].

2.6.8 Sound

As compared to a motion, sound can also be utilized as a strong attention-seeking cue as much as motion [44] [58] [53] . According to Bartle, both Killers and Explorers are also heavily guided through sound [4]. This orienting response to strong stimuli is automatic and is associated with our evolutionary survival traits [6]. These unexpected, novel, and potentially dangerous cues, will take a high priority and will be processed and pursued first [6]. We can alter the player's attention with these cues and physically draw them toward the stimuli's source.

2.6.9 Sub conclusion

This section has explored several wayfinding techniques used in games; UI through the HUD is often used in non-linear or open area games so the player knows which direction they should go towards. Lighting is also used as a wayfinding cue and is an effortless attention attractor for the player. As well as having the main path through the game have more light than the side paths have, the player can see the contrast and move back to the main path if they are lost.
Breadcrumbs are term used for attention-seeking objects that pull people towards the desired destination. The objects used for breadcrumbs can be various as well as their purpose in video games; some can be coins the player needs to pick up or even enemies the player needs to defeat. Landmarks can be seen as a subset of breadcrumbs; they are usually quite prominent in-game so that the player can check their progress the closer they are to the landmark, and they can also use it to orient themselfs towards it.

Different kinds of chokepoints have also been explored one can be used to prevent all types of backtracking and is mainly used in linear games. The other type is that the player can backtrack once a condition is met. This type of chokepoint is prudent to make the player teach a specific mechanic the need to learn.
Teaching players through colours have been used in several video games, as has been discussed; thus, having consistent colour throughout the level that the player will learn to follow can help the player navigate through the game.
Given the player, a peak over the environment also has some wayfinding benefits, where they can see over the environment and see points of interest.
Both sound and moving objects are great attractors for the player's attention and can be used as effective wayfinding cues to direct their attention to a specific place.

To round off the section, the research group have found that light, motion, and sound are effortless attractors and are good elements to use as a navigational aid to players. Furthermore, colour coding specific elements you want the player to follow or avoid can also be used to aid the player in navigating the environment.
Breadcrumbs are an excellent help to the player navigating through the environment. The breadcrumbs themselves can also use some of the already mentioned navigational aid, for instance, light or a landmark, to help the player orient themselves towards the desired destination can also be used.
Different types of chokepoints can also be used to force the player's attention to a specific thing.
Lastly, providing the player with the high ground can also help the player with the layout of the area, where they might also be able to see other landmarks which they can orient themselves towards.

2.7 Final Problem Statement

This study has explored several spatial geometry and wayfinding techniques. Planning and sketching out the potential layouts using bubble diagrams and space syntax analysis as a tool, as mentioned in section 2.4, and design with movement and pathing in mind for the players, as mentioned in section 2.5, will be a compelling start to use at the beginning of the design process.

This study has explored three ecological models that can be used to explain urban growth and a city's geometric spatial layout (see section 2.3). The study has also found parallels with two models (multiple nuclei), how Divinity original sin 2 levels have been designed and sector theory, and how World of Warcraft's level zoning works. This suggests that it is possible to use these ecological models as a baseline for the overall layout in games. However, it should be noted that both Divinity Original sin 2 and World of Warcraft uses these layout in context to player difficulty in different areas and not in relation to wayfinding.

Player attention and how to attract the player to certain areas is also a tool that should be used when guiding players around a map (see section 2.2). Thus, two different kinds of attention processes were explored top-down and bottom-up, and it was found that the top-down process takes more energy from the player, therefore there should be a balance between the type of attention the player needs to do whether it is for the tasks or navigating them through the game, potentially allowing the player the breath through some parts of the game. Furthermore, the study has also identified three types of searches people do in games, which might be a prudent way of having a different navigational task for the player, and switching the attention process they are using.

There were numerous wayfinding techniques used in games, as mentioned in section 2.6, and many could be included in the design process. The wayfinding techniques, which use effortless attractors and more intuitive, seem to be the usage of light, motion and sound as they trigger our natural physiological response to these stimuli. Thus, these wayfinding cues will be utilized in the design process when guiding the player through the game level.

Lastly, this study has explored the five Lycian elements which are seen as good architectural elements that help people to create a mental image of a city (see section 2.1). These elements will also help people to identify different areas of a city to help them navigate around these five elements should be included in the design progress.

Many types of wayfinding techniques has been explored and different types of grabbing the players attention has also been explored. This study found that the model multiple nuclei can potentially be used to create less intrusive way of creating a linear experience for the player, but there have not been much research in regards to how different types of level layout has an effect on navigating the player through a level. The concentric model, forces the player to go through each of the zones there is in the level independent of which direction a person goes through from the center. The sector model is much more homogeneous, meaning, dependent on the direction the person will only see the same theme/ district/ identity throughout the path. Based on that a sector model might be much more predictable for a player going through a city, suggesting that it might be easier for a person to navigate or at least differentiate between the different homogeneous areas in the town. The research group, therefore, suggests that a sector model might be easier to differentiate between the different areas than concentric and multiple nuclei, due to the homogeneous of its design. This aspect let the research group to see if the different ecological urban models, sector theory and multiple nuclei specifically, can be used to help people navigate in an environment, and not only to be used as difficulty zones. This led the research group to the final problem statement:

> "To what extent does a linear game based on sector spatial layout have an affect on a player's perceived wayfinding when compared to a linear game based on multiple nuclei spatial layout?"

3 Methods

Based on the final problem statement.

> "To what extent does a linear game based on sector spatial layout have an affect on a player's perceived wayfinding when compared to a linear game based on multiple nuclei spatial layout?"

the research group first needs to find out if there was a significant difference between two different spatial layouts when it comes to a player's perceived wayfinding. This led to the following hypothesis:

> H0 = There is no significant difference between sector layout and nuclei layout can affect a player's perceived wayfinding in a game.

> H1 = There is a significant difference between sector layout and nuclei layout can affect a player's perceived wayfinding in a game.

A mixed-methods evaluation was used for this experiment. A quantitative method was used to test the hypotheses, and a qualitative method was used to collect data through interviews and comments to interpret the quantitative data. A JSON file was used for observational method to interpret participants pathing and behaviours through the map between both conditions.

3.1 Data Collection

A Between Subject was designed, and an explanatory sequential mixed methods [8] will be used to test the hypotheses and answer if there was an effect between participants perceived wayfinding between both layouts and then compare the results later, and discuss whether the participants perceived wayfinding was affected and to what extent. All the data are collected through questionnaires, the game and semi-structured interview.

A questionnaire is used for their perceived wayfinding through a self-assessment ranking score through a 5-point Likert scale. The uninstrusive data will be saved through a JSON save file, where the player's positions and time will be used to research the participant's movement and behavior between both conditions. After each prototype testing, every participant will be asked save a JSON file from the game to the questionnaire, and if they would like to do an semi-constructed interview regarding the game and how they felt going through it.

3.2 Construction of questionnaire

The questionnaire was constructed and divided into 3 sections. The first section is the demographic part, followed a Quantic foundry motivation model for their motivation type when playing games [48]. The reason for this is to get an understanding for their pathing through the JSON file. This is followed by how many hours they play games per week and how good their sense of direction is.

Second section are the perceived wayfinding questions. A 5-point likert scale of perceived wayfinding containing 14 subscales was used for this section [23]. Each questions are divided into 3 constructs of Perceived Spatial Complexity (Describability) is about the players general understanding of the spatial layout of the town [23], Anticipated Wayfinding Difficulty (Simplicity) measures players perception of their path in the town instead of the general layouts in regards to a specific location [23], and Remembrance (Memorability) assesses how the layout are stored with the players in episodic memories according to Lawson's research [36].

Third and final section are uploading the JSON file for their play session. The JSON file contains the position for the participants and is updated every second throughout their play session.

3.3 Procedure

The participants was gathered with convenience sampling through both online and offline recruitment. Each participants will first have to read the consent form and if they agree to participate in the study and can dropout if they so wish. Once they have agreed to the consent form, they will answer some demographic questions, followed by some questions regarding their motivation type playing games, and what they perceived their sense of direction to be. Once they complete the

demographic part, they will provided with a link to the game which they can download and play. Once they complete the game, they will be asked to return to the questionnaire and continue to answer some questions regarding their perceived wayfinding e.g. if they had difficulty finding way to certain landmarks on the map. Once they finish the questions, they will asked to upload a JSON file for their play session.

The research group does expect some data to be lost, for instance, some save files due to the lack of supervision and guidance the research group otherwise could have provided the participants.

3.4 Data Analysis

The data gathered from the questionnaire are ordinal, and each group is independent of each other, which means that a non-parametric tests such as Mann-Whitney test can be used. A Semi-structured interview for a few selected people of each group. Traditional coding was used for organizing, recognise and interpret the transcripts of the interviews to find patterns [8]. Keyword analysis was used for the comments in the questionnaire For the JSON data (player position map) the research group will analyze the data within five overall categories: the general movement within each quest, differentiation between the participants who follow the fire spirit, and those who found their own way (see quest design 4.2.4). The research group does not expect much exploration when the participants has reached the last quest.

4 Design

The following sections will elaborate on the design process for this project. It starts with pre-production, where ideas, sketches and diagrams are created as suggested in section 2.4. Afterwards, the research group entered production to implement each town to sketches from the pre-production. Then, based on the game mechanics discussion from the pre-production, game mechanics such as movement and hammer throw/recall were implemented. Lastly, a VFX asset was created for one of the mechanics discussed during pre-production.

4.1 Pre-production

The bubble diagram was created to understand the space syntax between each area and how each town can be constructed. The sketching is an elaboration on the bubble diagrams to understand better how big each area has to be to each other. The game mechanics were discussed, and to work on the boss who will be introduced at the end of the game and make each quest related to a certain mechanic which the player will learn before encountering the boss.

4.1.1 Level design

The research group started by discussing interesting game mechanics. It was decided that a game mechanic inspired by the axe from the god of war would be an interesting mechanic to use, it was then thought that it would be a good idea to give the player a hammer-like Mjöldnir from north mythology. It was then decided that a Viking/fantasy style of the game would complement the game mechanic. Different types of zoning elements were then discussed these elements should be possible to identifiable for the player, and based upon the different kinds of content of the different zones was described in section 2.3.
The research group thought that different types of economical levels of housing would be a good identifier for the different zones meaning low residential, high residential, and processing shops like butchers and blacksmiths areas, in addition to that a marketplace that should work as the central business district (CBD) was decided. Four other notable landmarks were also decided that the city should include these was a castle/ a big manor, a church, a park, and a harbor these landmarks and districts can be seen in figure 13 and 14.
As mentioned in section 2.4 and 2.5, there are several ways and tools to start the design of the level in video games, the research group started therefore by creating a bubble diagram of both the levels based on the districts and landmarks mentioned earlier these bubble diagrams can be seen in figure 13 and 14.

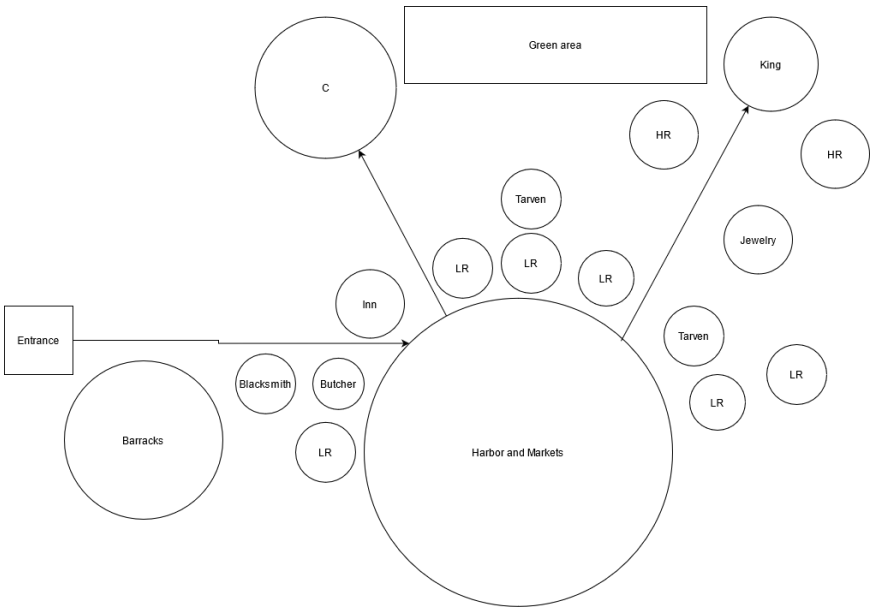


Figure 13: This figure is a diagram of how the sector layout will look in relation to various elements in the town. This was made in draw.io

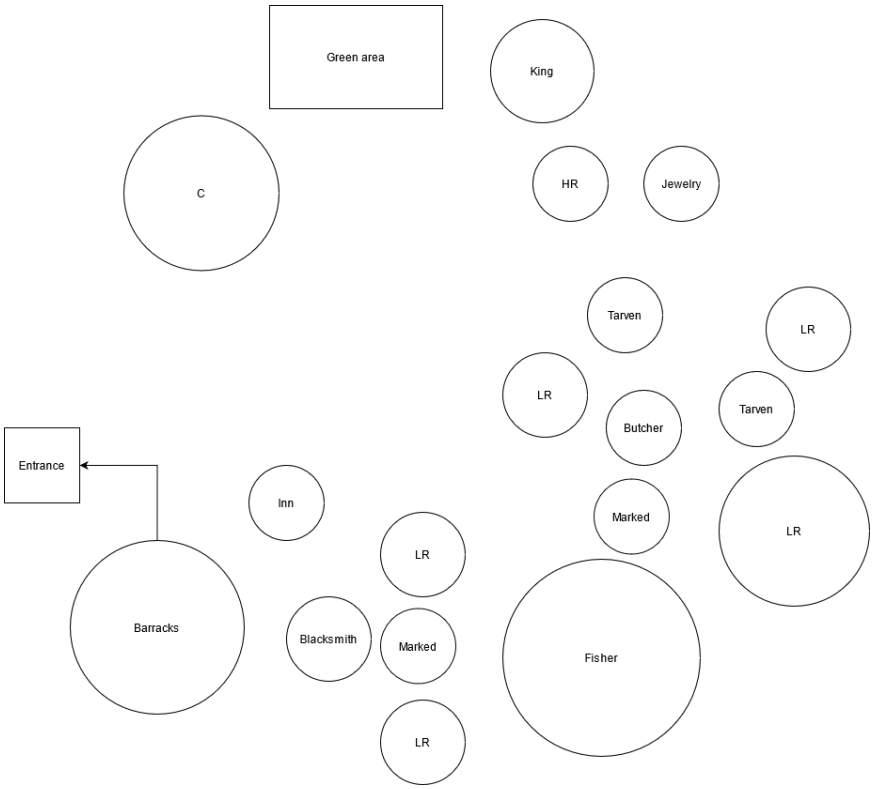


Figure 14: This figure is a diagram of how the multiple nuclei layout will look in relation to various elements in the town. This figure was made in draw.io

After the bubble diagrams were created, drawings based on the figure-ground technique which was mentioned in section 2.5, the drawing were also drawn to be able to see the space syntax of the two levels, the two drawings can be seen on figure 15 and 16.

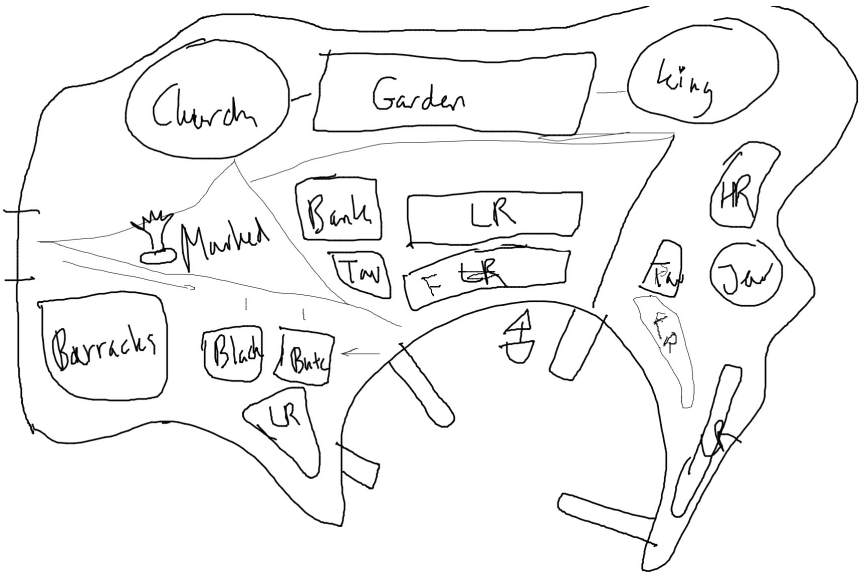


Figure 15: An elaborated illustration of how the sector layout would look in concept based on previous diagram from figure from 13. This figure was made with sketchpad.pro

Figure 16: An elaborated illustration of how the multiple nuclie layout would look in concept based on previous diagram from figure from 14. This figure was made with sketchpad.pro

Lastly, it was decided that it would take too long to model all of the models that would be needed to create the two levels, so two assets were bought. However, later it was discovered that the amount of houses that was gathered from these assets was not enough to supply a whole town see section 4.2.1.

4.1.2 Game mechanics tutorial quest

The research group wanted to design the quest where the player would learn the game mechanics in relation to how the player would be able to defeat the boss. Thus, first the boss's weaknesses were discussed and decided followed by its attacks. It was decided that the boss should be related to the harbor to have a reason for having a harbor part of the design, in Norse mythology, there is a ship made by fingernails called Naglfar [30], which the research group chooses to use as boss.
This would also complement the theme with the player's hammer. The boss would shoot toward the player with canon balls kinda like a ship-to-ship battle. Its weakness should be something immediately identifying, the research group decided on big chunks of ice on the ship which they needed to destroy to defeat Naglfar see figure 17.

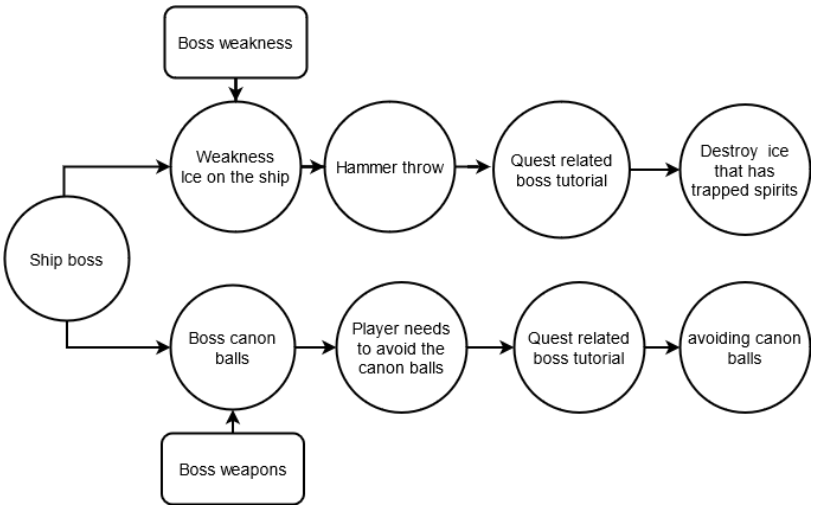


Figure 17: This figure illustrates the idea of how the boss can have several components to what the boss does and what the boss is weak to, and how we utilize this to other aspects in the game. This figure was made with draw.io

After the boss diagram was created it was decided that the first quest should focus on making the player learn how to use their hammer, this was done by first making them sink a few ships in the harbor, then they should find a spirit trapped in ice which they should free it by destroying the ice see figure 18

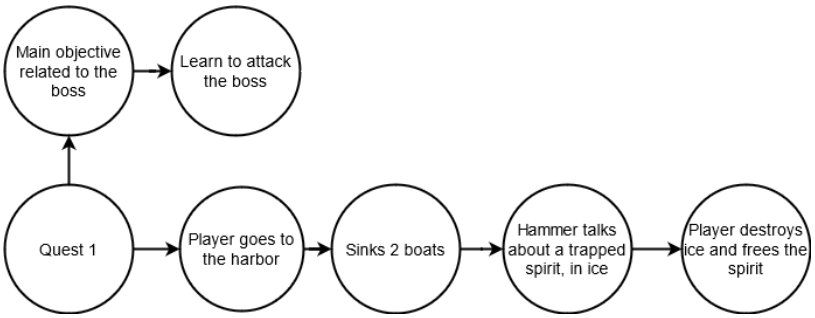


Figure 18: This figure illustrates how the player will progresses in the first quest. This figure was made with draw.io

For the second quest the player needed to avoid the boss weapons, however the player should not be able to defeat it with the hammer since, the purpose of this quest was to learn the player how to avoid the boss weapons and not defeat it, in addition the player only should associate the ice as something that can defeat the enemies see figure 19. It was then decided that the player should turn on some bonfires which would make the enemy flee from the area.

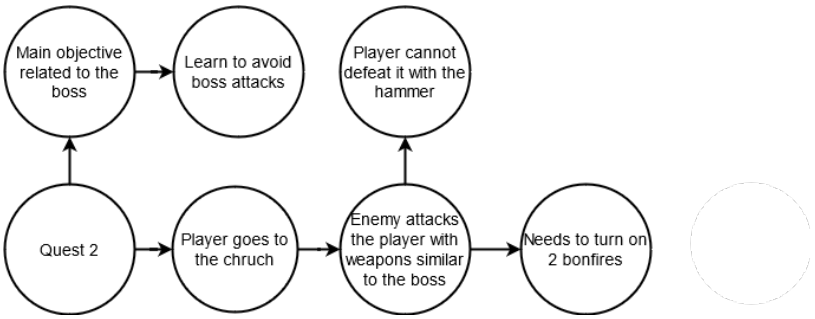


Figure 19: This figure illustrates how the player will progresses in the second quest. This figure was made with draw.io

4.1.3 Gameplay Loop

The gameplay loop for the player starts when the player picks up the hammer, and starts a new quest which leads to a whole quest chain to complete the game. This gameplayloop can be seen in figure 20.

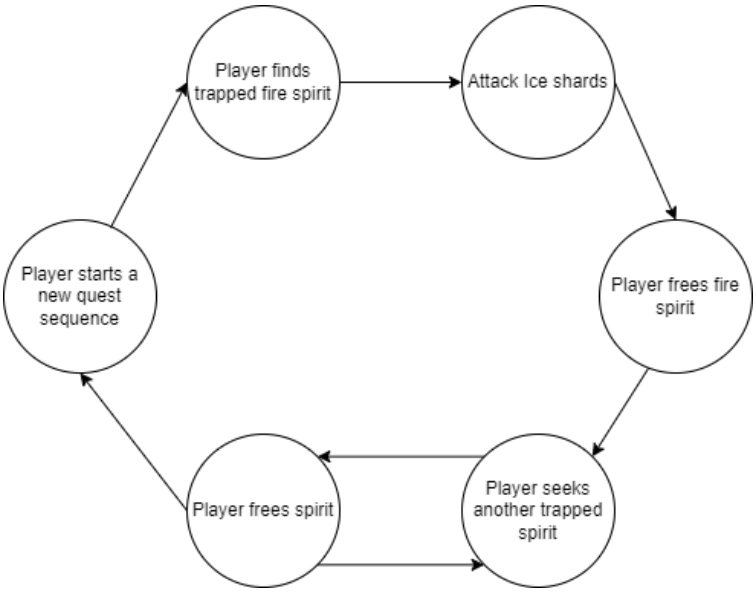


Figure 20: This figure illustrates the gameplay loop which the player will experience throughout the game. This figure was made with draw.io

4.2 Production

This subsection will go through the design through the production phase, it will first go through some prerequisites of some of the design decisions. Then the two different layouts will be explained and lastly, the different quest structures will be described.

4.2.1 Prerequisites for the level layouts

Before going into the design of both the multiple nuclei and sector model designed levels (see section 4.2.2 and 4.2.3 respectively), a few things should be noted. As it was mentioned in section 2.3, the three ecological models that were mentioned there were based on urban growth doing the 20th. century, thus many of the same types of zonings do not match the types of zones that would normally be found in a Viking / fantasy setting, so the designers had to change some of the types of zones to fit the setting of the game, while still keep the core meaning of the different ecological models from section 2.3.
First of all the designers made the assumption that in general big cities before the industrial age tended to be big if they were trade cities and has a harbor. Second of all, a manor for the lord of the city or a religious temple would be a requirement for a big city doing the time of the setting of the game. In the drafts of the city, it can be seen that the drafts include a marketplace, harbor, lord manor, and a religious temple, which can be seen in figures 15 and 16.
Other types of zones from the ecological model which did not fit the setting of the game were the different types of manufacturing zones. So instead of having different types of manufacturing zones, different work types zones were decided to better fit the setting which are: the barracks, inn, and laundry zones. In the drafts that were mentioned earlier and described in section 4.1.1 there were more different types of shops this was changed due to the different types of models the designer was able to accrue. Lastly, since the town has a harbor, which would be one of the main ways the city would get and sell resources, the last zone that was added was warehouses to store gods, around the harbor.

As was mentioned in 4.1.1 it was decided to gather premade assets for the project thus two groups of medieval and Viking inspired assets were bought. However, there were only seven different houses with those assets [21][60], thus the designers chose to edit the houses using Autodesk Maya, in order to gain more different types of houses, here the designers choose to use the three different

roofs that were gained as the identifiable zoning characteristic for the different zonings in the levels so the low residential area in the prototype would consist of a thatched roof, the middle-income area in the game would be shown with wooden roof and lastly the high residential area would be shown with Roof tiles.
The reason for this is due to the material cost of these different types of roofs. Thus making it an understandable and easy identifier. An additional house was created through parts of two different houses just to have an additional house to use. It should be said that the research team does acknowledge that the small amount of different houses in the game might create some uniformity and might even cause some navigational confusion, due to the uniformity or repeated houses. The boss ship model was from [51]

4.2.2 Multiple nuclei level

The multiple nuclei model has four rules as mentioned in section 2.3, which in short is: 1) some zones require more land than others. 2) Zones where profit is earned which is not produced within the city take place within a cluster of shops.
3) Some Zones are damaging or in conflict with each other which will result in one of the zones' categorizations will not exist if they are next to each other. 4) Some zones are restricted for other people outside of the zone due to for instance capital, thus a high-income zone will restrict people from low income to live in that area.
The different zoning's for the multiple nuclei level that was designed can be seen on figure 21.

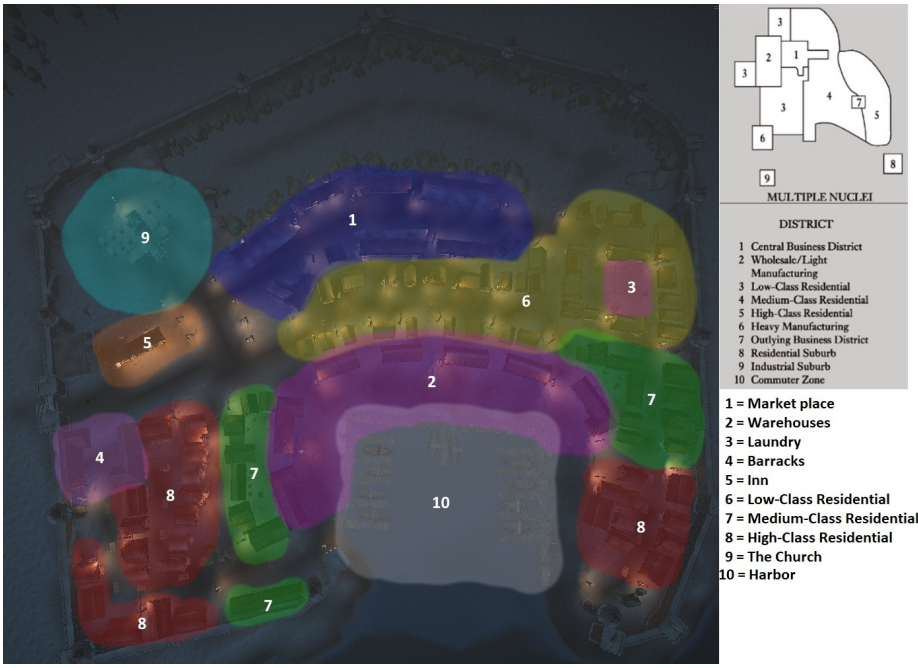


Figure 21: This figure shows distribution of the different districts in the nuclei layout.

As mentioned in section 4.2.1 the design of levels uses different types of zoning categories than there is in the original ecological models that were mentioned in section 2.3. The designers have also taken some liberty with some of the constraints of the patterns to the models, to better fit the design.
The most important pattern in figure 21 which also matches the nuclei layout requires that the high residential cannot have the low residential zone as neighbors, thus the medium residential zones are used as a buffer zone between the two zones which can be seen on the right side on figure 21. Furthermore, the medium residential zoning is also used as a buffer zone between the high residential and the warehouse zone on the bottom left on figure 21.
The designers took some liberty with the high residential zone and the barrack zone, this was due to it would make sense that there would be a military presence close to the main gate of the city and it was a higher priority that the high residential zone should be far away from the market place and the lower residential zone.
As was mentioned in section 2.3 the multiple nuclei model differs from the concentric and sector

model in an important way the pattern is not built around the central business district. So it was decided that the marketplace to be represented as a straight path, that was not a direct path from the path of the main gate.
To make the city look like a people also would live there and subcommunities also were a possibility, "small public squares" was implemented within the different housing clusters [2], Totten calls these areas public-private areas, meaning that the areas an in public places but the houses (in this instant) are used to cover up the area to give a more private feeling when people are within the area.
These areas can be seen on 22 where it is painted blue, here the different inhabitants of the zones could meet up, socialize or have a small community meeting. Within these small public squares, a well was also placed to make it a place where it would be assumed by the player that it would be normal for the inhabitants of the cluster to use the area.

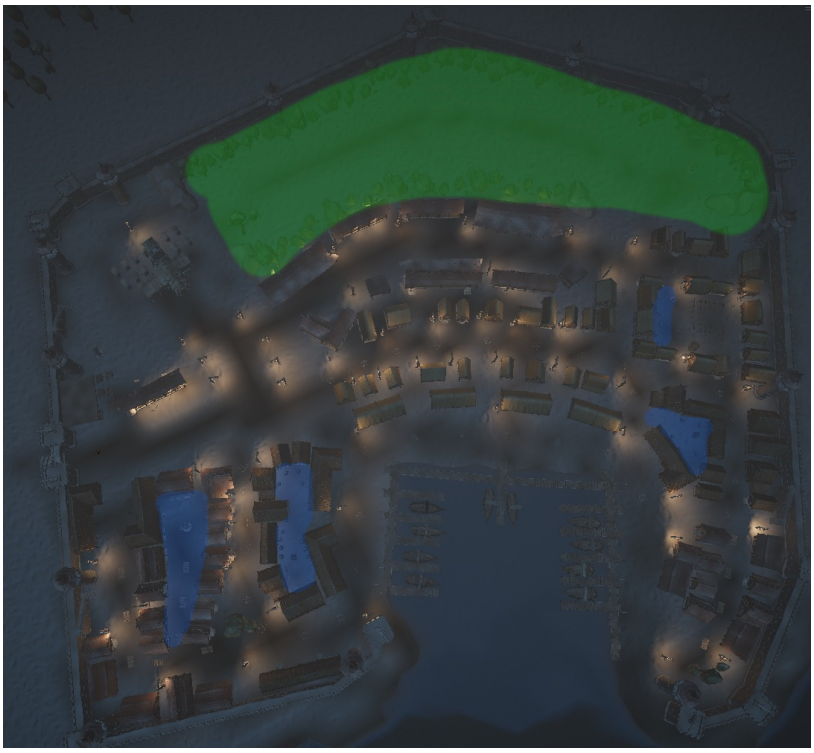


Figure 22: This figure shows how the green areas that were meant to be the garden and blue area being open public areas based on concepts for the nuclei layout.

Doing the design implementation of both sector and nuclei it became clear that, it would be too much to have both a religious temple and lord house, thus the designers agreed that the levels should only include a religious temple. However since the original drafts of the layouts see figures 15 and 16. The green garden was designed to have the lord a private and beautiful path to the religious temple, see the green area on figure 22. However, since the lord's house was removed from the design, the designers still wanted to have some green within the city to have more variations of color in the town, so the garden stayed within the level, the garden in the nuclei model is more true to the draft design that the section model, this will be mentioned later. However, in retrospect, the garden in nuclei could have been made smaller to include more housing clusters to make the city a bit more complex or move the religious temple to a more central position.
The designers are still of the opinion that it is a good idea to have included a "Green area" in the town Alexander states that green areas are good for the inhabitants of a town, and due to the size of the city, one garden would be enough since there is less than three minutes walk to it any were in the town [2].
The Lynchian elements which were mentioned in section 2.1 was identified to help the people to create a mental map over the environment which helps people navigate in an environment.
The Lynchian elements were also used as part of the design of the level, the Lynchian elements are paths, edges, districts, landmarks, and nodes.
Figure 21 shows the different districts of the level, on figure 23 the rest of the Lynchian elements can be seen, the green dots / subjective landmarks in figure 23 well be described more in section 4.2.4.

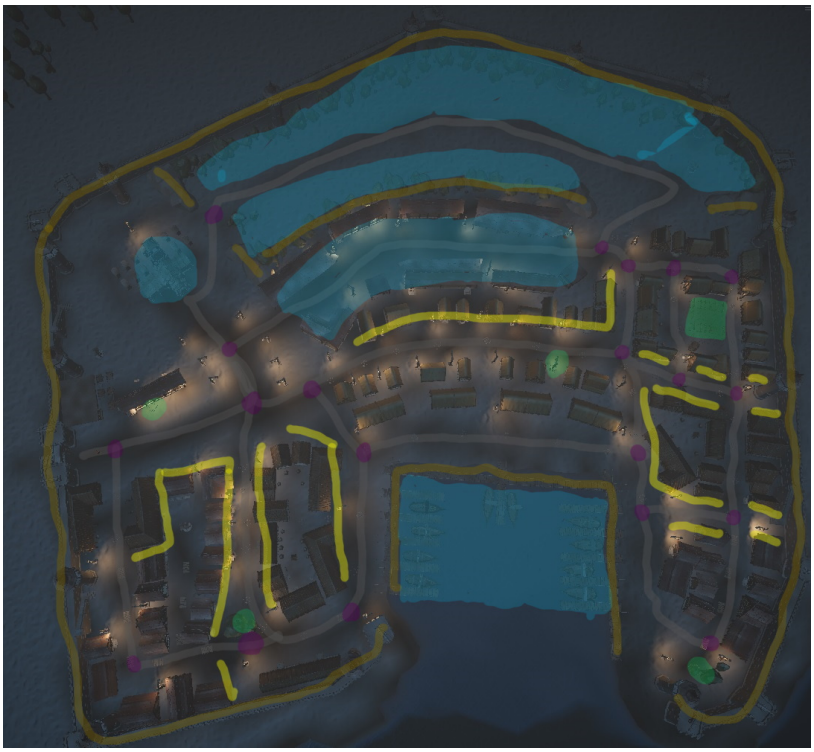


Figure 23: This figure shows the different Lynchian elements in the multiple nuclei level. The dark yellow color indicates the edges where it is not the buildings that create the edge, the light yellow shows the edges that are created by new types of buildings that create the edge. The grey lines show the paths in level. The purple dots show the nodes in the level. The blue areas indicate visually distinct landmarks. The green areas show subjective landmarks which the designers wanted the players to remember.

4.2.3 The sector level

The main characteristics of the sector model are that the different districts are built around transport areas for instance main roads, and each area is mainly homogenous, as was mentioned in section 2.3. As was mentioned in section 4.2.1 the roofs of the houses were used as the main identifier for the districts identifier, thatched roof, wooden roof, and roof tiles on figure 24 the different zonings of the sector model can be seen.
The sector model is built around the central business district, so it was decided that the sector model should also be designed around the marketplace. The top side of the level is the high-class residential area as can be seen in red on figure 24, which ends up with the church since the designers assume that religious temples are generally more wealthy than most people who live in the town.
There was designed two main routes on in the level, the first main path is the paths that goes through the town where the lower and medium class is build around, and the main path from the church to the road mentioned before.
There was some deliberate design change from the original sector model and the level, as was mentioned in section 4.1.1 it did not fit the setting of the game to include manufacturing districts, so the light manufacturing district widgets from the original model on marked as zone 2, which can be seen on figure 24, was changed to be the medium residential class.
An additional visual signifier that was used to show the difference between the districts, was stone and wooden pathways, for the lower and medium residential districts stone pathways were used as an additional layer to the roads that lead through the districts, and in the higher residential district wooden pathways were added as an additional layer to the roads.

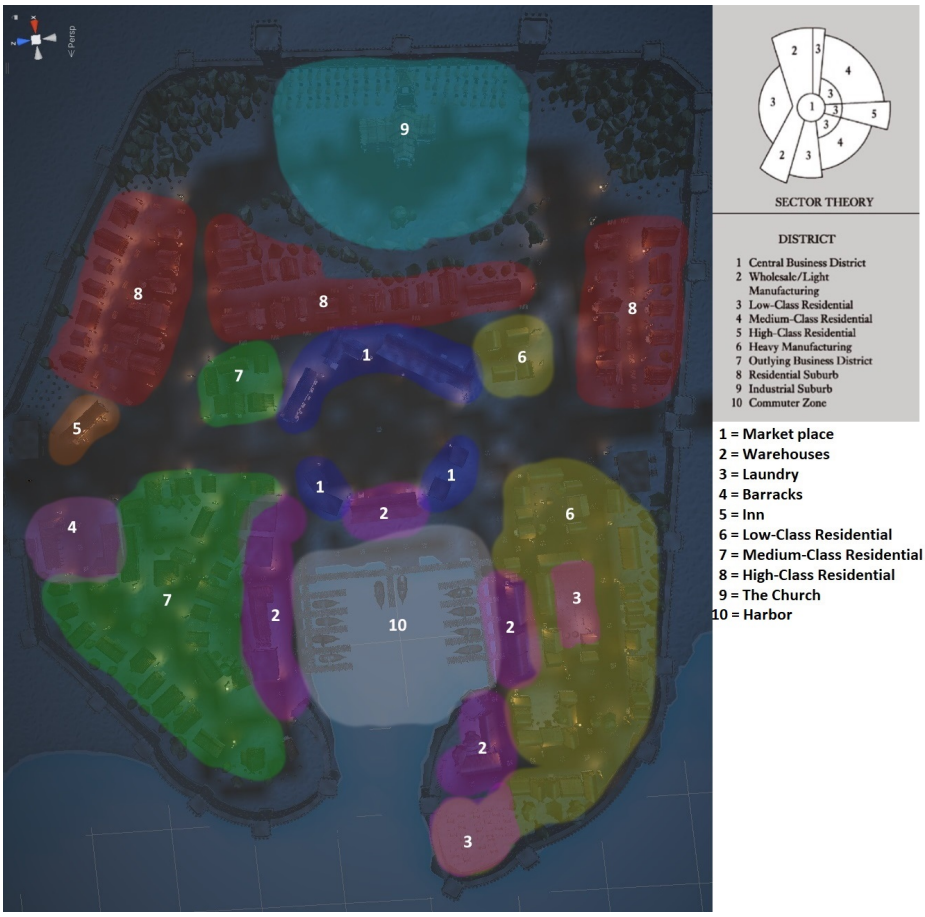


Figure 24: This figure shows distribution of the different districts in sector layout.

Since it was decided to remove the lord's manor from the level, as was mentioned in section 4.2.2, the church was moved to a more central place on the level, and trees were placed around the church to one differential the area and to be used as a small shield from the rest of the city, the trees from the front of the church towards the high residential areas were also placed to be used as small green areas these were meant to replace the green garden which can be seen marked as green on figure 25. As was mentioned in section 4.2.2 the designers thought it was important for the town to include small public areas, where the inhabitants could meet locally, these areas can be seen in blue on figure 25. In the sector model.

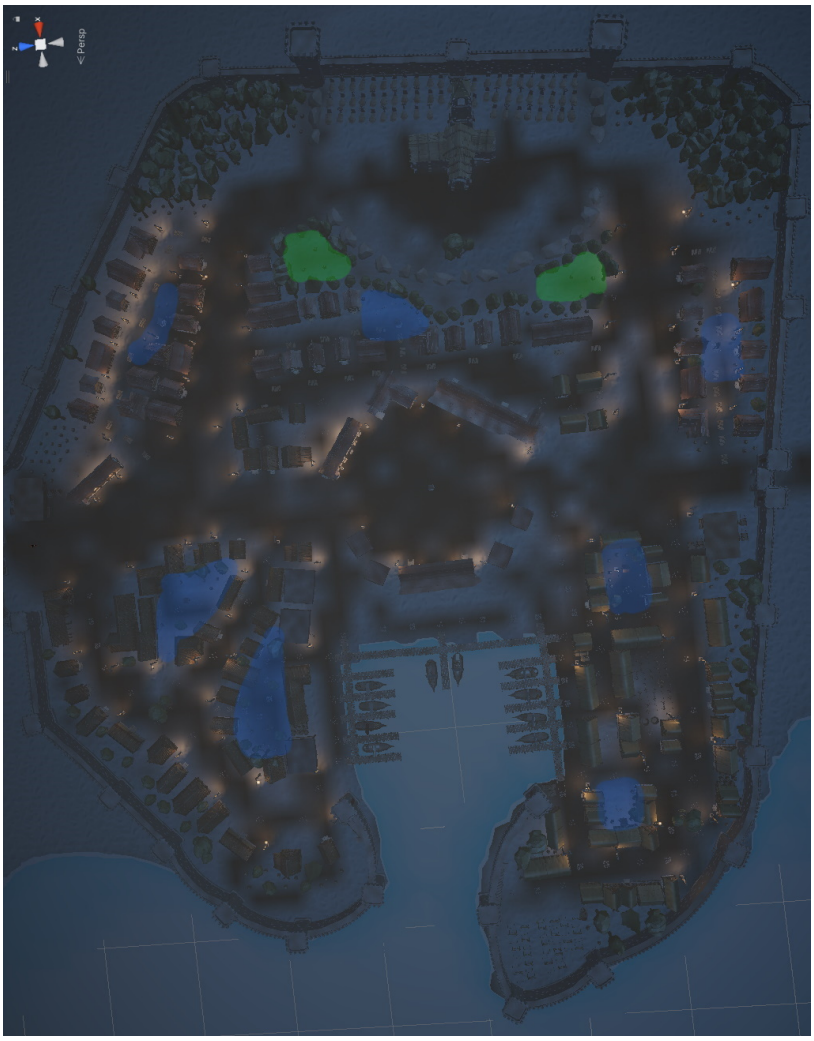


Figure 25: This figure shows how the green areas that were meant to be the garden and blue area being open public areas based on concepts for the sector layout.

In the sector level the church was placed on a hill, to make it easier to for the player to see it far away, it is also surrounded by rocks, these rocks are used as a visual signifier for a trigger box that is used to activates the ice spirits attacks towards the player see section 4.2.4.
The harbor's polder for both the nuclei and sector level was inspired by the polders used in the city of Novigrad from the Wither 3. This was done because the designer through it gave a good visual effect, where the harbor area is quite big and the close to the sea the player can see the narrower the sea gets until the sea leaves the city area.

Figure 26: This figure shows the different Lynchian elements in the sector model level. The dark yellow color indicates the edges where it is not the buildings that create the edge, the light yellow shows the edges that are created by new types of buildings that create the edge. The grey lines show the paths in level. The purple dots show the nodes in the level. The blue areas indicate visually distinct landmarks. The green areas show subjective landmarks which the designers wanted the players to remember.

As was mentioned earlier in section 2.1 and in 4.2.2 the Lynchian elements can help people create a mental map over the environment, on figure 26 the elements can be seen on the sector level. Due to the homogenous nature of the sector model, the edges in the sector model are more balanced/symmetric than the edges in the nuclei level figure 23, where nuclei have more districts in the overall spatial area, it will be interesting to see from the results of the test if the differences have an effect on the players' perceived wayfinding technique. Lastly the green dots / subjective landmarks in figure 26 well be described more in section 4.2.4.

4.2.4 Quest design

This subsection will go through the player's introduction to the game and the quest design in chronological order from start to end. On figure 27 all the quest and their positions can be seen.

Figure 27: This figure shows the quest layout at the sector level. The numbers represent the which order the player move toward each quest from 0 to 11. The white circle shows where the player starts the game. The yellow color is where the player picks up Mjölnir. The numbers within the turquoise and brown color indicate a quest area, where one or multiple quest take place within the area. The dark blue color indicates where the player needs to sink two ships. The pink circles show where the trapped fire spirit is. The red color indicates the positions where the player needs to search for other trapped spirits. The green circles indicate where the bonfires are, of which the player needs to turn on, to complete the first part of the second quest. The purple circle indicates where quest 3 will start.

The introduction to the player starts by an short cutscene where the hammer is in focus falling down from the sky and hitting the ground, the camera is then moveing back towards the player while still is looking at the hammer until the player character can be seen then the player will gain control over the character. This was done to show the player were and what they should do in the beginning of the game. Once the player has reached the hammer and picked it up the hammer will starts by giving the player some exposition of who/what the hammer is (Mjölnir) and where it came from, to see the players start position and Mjölnir's start postion see the white and yellow circle on figure 27.

The first quest sequences starts where Mjölnir ask the player to go to the harbor and hit two ships so they sinks, the harbour is positioned fairly closed to where the player picks up the Mjölnir, see the yellow and blue circle on figure 27. But will not be able to see it from where the player picks up the hammer thus the designers expects the players to use naive search to find it and the designers does not expect it to be difficult to find.
The harbour sequence was done to one let the player learn the hammer throw mechanic see section 4.3.1 and a foreshadowing technique for what will happen at the end of the game where the player again will be at the harbour and an ship name Naglfar will come and destroy the harbour and the remanding ships which will be mentioned later in "the thrid quest".
After the player has sunked two ships a ice crystal will rise at the right end of the harbor in the same side of the town of where they started the game, see the pink circle 2 on figure 27, Mjölnir will then ask the player to go to it and free the spirit. The ice crystal will have a fire spirit trapped within it, and fire spirit will also emit light to gather the players attention, see figure 28. The placement

of the ice crystal and a none to descriptive dialog to guide the player was a design error based on some of the interviews some of the players did not see the ice crystal, and it took them some time to find it.

Figure 28: This figure shows the fire spirit which is trapped within the ice crystal, which the player needs to free. The tree within the yellow circle is the tree player needs to find after having freed the fire spirit.

The first search quest line is a subset of questline designed to make the player search for different positions thus creating subjective landmarks for the player (see section 2.1).
Within these questlines, the player will be given a direction and objective they need to find to progress. This was intended to give the research team interesting behavioral movement data which they then would be able to analyze see section 3.4.
The search questlines will always be activated after the player has freed a fire spirit this was because, after the fire spirit is free it will move through the level and move past the different objects the player needs to find, in addition to that each time the fire spirit moves past lamppost it will turn them on. This was designed to help the player if they got lost or were not sure where to go, then the player could either try to follow the fire spirit or follow the lamppost which was turned on. However as a disincentive to the player, so they would not just follow the fire spirit, its movement was slower than the player's normal walking speed, thus making it feel like a boring escort mission.
Once the player has freed the fire spirit, Mjölnir will tell the player that there is a trapped spirit in the tree surrounded by flowers close to the player, see the trees position in relation to the ice crystal on figure 28 and to see the trees position from a top down view see the red circle 3 on figure 27, if the player has the harbor behind them else they would have walked past it. Once the player has interacted with the tree Mjölnir will tell the player to go to the inn which was near where the player found it, where there also is a circle of flowers, see the red circle 4 on figure 27.
The designers expect that both of these places will be easy for the player to find and even know that part of the town well.

The second quest sequences after the player has found the inn Mjölnir points out that something is happening with the church, and the player needs to go there, Mjölnir also tells the player about some evil spirits called ice spirits which are also at the church, see the brown square on figure 27.

To visual guide the player towards the church, if they are not sure of which path will lead them to it, all the lamppost from the inn and on the street leading up to the church are turned on hinting to the player that they should go that way.
The purpose of this quest was to learn the player how to avoid the boss's attack so when the player goes into the church area the ice spirit will attack the player with the same type of attack as the boss will do a type of elemental area attack (see VFX design in section 4.4).
The church will look frozen and will have a bonfire on each of its sides, see the two green circles on figure 27, of which the hammer tells the player that they should turn on by getting close to it and press e, where then a fire will appear. To make the bonfire look more notable and more attractive to the player before they are turned on they will burn with the white blue firelight, similar color to the ice spirit see figure 29.

Figure 29: This figure shows the church which is looking frozen, the ice spirit, the bonfire which is burning with blue firelight which it looks like before the player has interacted with it. To the right is how the bonfire looks like after the player has interacted with it.

Once the player have turned on both of the bonfires another ice crystal will appear with a trapped fire spirit, see the pink circle 7 on figure 27.

The second search quest line starts after the player has freed the fire spirit, where Mjölnir will tell the player to find where the people of the town does their laundry on the other side of the town, where there will also be a circle of flowers at the laundry area, see the red circle 8 on figure 27. The designers does except this to be a more difficult task for the players to find, since they have not been in that part of the city yet (or a least supposed to) however the area should is quite recognizable see figure 30, so the designers expect that once the player has moved through that part of the town they will know where it is.
After they have been at the laundry area Mjölnir will tell the player about another tree also surrounded by flowers further down the path, see the red circle 9 on figure 27.The designers do except the tree to be easy to find.

Figure 30: This image shows the laundry place the player needs to find.

The last part of the search questline has two different ending parts depending on the condition the player is in. Since the designers did not want the player to have a too long way to the last quest.

So the final position for the multiple nuclei is on the street before the marketplace and next to the harbor see the left figure on figure 31, and might be harder for the player to find than it the last position in the sector condition. For the sector condition, the player will end up at the marketplace next to the harbor, see the red circle 10 on figure 27, and needs to find the lamppost shown on figure 31

While the player is searching for three places mentioned earlier the Mjölnir will also give a foreshadowing for what is about to happen, Mjölnir mentions that it might not be Ragnarok at all seems Mjölnir have not seen Naglfar yet.

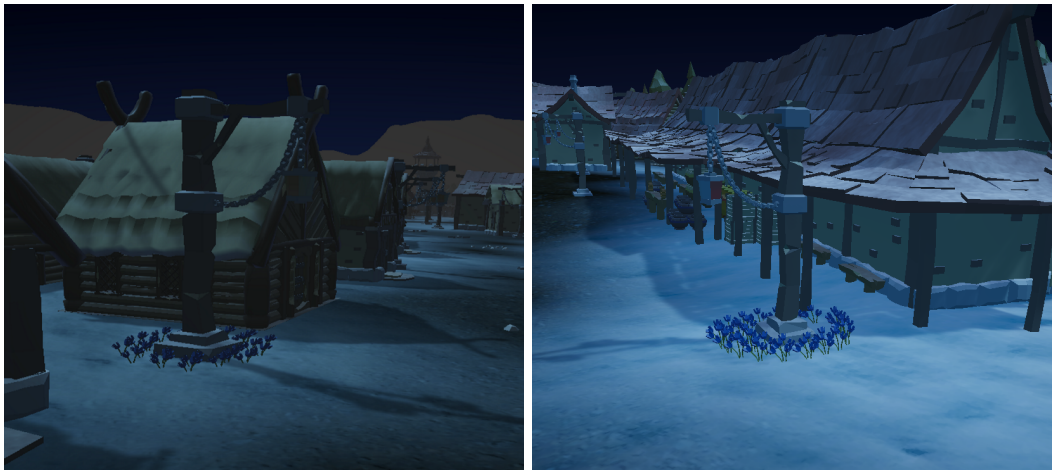


Figure 31: The figure to the left shows the last position the player needs to find in the multiple nuclei condition. The figure to the right shows the last position the player needs to find in the sector model.

The third quest As was mentioned in section 4.1.2 The designers wanted the boss of the game to be related to the aesthetic theme (Viking fantasy) and to be able to utilize the harbor more for the game, so it was decided to have the end boss to be the ship Naglfar from Norse mythology.
However to give a more visual indicator for the player to how to defeat it the ice crystals were chosen to be the visual indicator for the player, of which the player has destroyed the previously to free the fire spirit as mentioned earlier.
The ice crystals were placed on the left, right, and side of Naglfar. In addition to the ice crystals, ice spirits were chosen to be passengers/ a visual indicator for what type of attack the player should except the boss. The ice spirit was thought of being a good signifier because the player had heard of them through the dialog from the hammer, and the player had met one of them in the encounter at the church where the purpose of the quest was to learn the player to avoid the boss attack.
Naglfar is introduced through a cut scene where the camera moves towards where the boss is, this was to indicate where the player should go after the cut scene, see the purple circle 11 on figure 27. The player will then see Naglfar rises through the water and move slowly towards the harbor, it then starts shooting to the left and right side of the harbor which would destroy those parts of the harbor and the ships, while a slow drumming and war horn was playing in the background, at the end where Naglfar is sailing through some of the harbor, which also sinks was meant to show it was a strong ship, after that the camera will move back to the player where the player was given control again, figure 32 shows Naglfar.
This sequence was done to both grab the player's intention and to indicate that Naglfar is dangerous, and it could also have an effect on the game's environment. Working quite well with foreshadowing from the beginning of the game.

Figure 32: This figure shows Naglfar the end boss, on the sides and front is their ice crystals its weakness, which the player needs to destroy to win. there are also three ice spirits moving around the ship.

4.3 Game Mechanics

There are three types of game mechanics for this game: Interact, Hammer throw and recall, and movement. Interact allows the player to interact with various objects in the scene that are relevant to quest and gameplay of the game. The hammer throw and recall, and movement is explained later in the following sections.

4.3.1 Weapon Throw and Recall

Hammer throw and recall is inspired by the Kratos' Axe from the game God of War. The throw can be used on certain objects in the scene to train the player intuitively on what types of objects to use it on. When the hammer is thrown, the player can immediately recall the hammer back to them, which allows the player to repeat this mechanic.

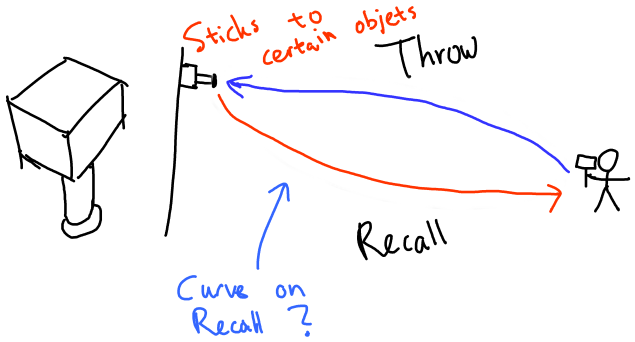


Figure 33: A game mechanic inspired by the recent God of War games. It's based on the Axe throw and recall mechanic where the player can throw the axe and it could stick on enemies, objects and structures and be recalled by another button press

4.3.2 Movement

The mechanics of movement can be divided into various degrees of execution: Walk, Run, Climb, Jump and Sprint [49]. Each movement is considered a fundamental part of any sort of game, but there are games without these movement mechanics. Most of this depends on the genre, what the objective of the game is, and how the developers can give the players the tools to play and complete the game. In accordance with section 2.6.6, it would benefit the player if they would be able to get on a high ground therefore the jump mechanic was designed so the player was able to jump high enough to get on the roof of the buildings in the game. This will give them the opportunity to scan and observe the surrounding area from a higher position. The jump mechanic in this case helps players get a view of the layout of the town they are in, which can prove to help improve their mental map of the town.

4.4 VFX

For this project, it was decided to have a shock blast effect for the enemies in the game. First, sketch was created in the following figure 34, following the VFX principles of anticipation, impact and dissipation [64]. Anticipation is about what a person expects the explosion to be before the next step which is impact. Impact has a shorter duration than Anticipation, and shows the real impact of the shock blast. Dissipation is the aftermath of what the impact has caused, leaving a mark on the ground and fade out over time [64].

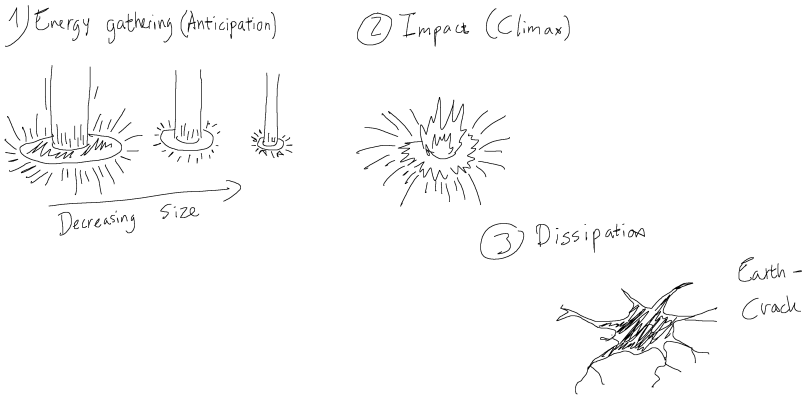


Figure 34: A VFX sketch regarding one of the challenging mechanics inside the game. It's based on the VFX theory of Anticipation, Impact and Dissipation [64].

5 Implementation

The following section covers some of the more essential code implementations for the project based on things discussed in section 4.

5.1 Hammer Throw and Recall

From section 4.3.1, a game mechanic was designed and further implemented. First, a set of global variables was made for the mechanic's following aspects: Hammer position, curve point, audio sources, and positions of multiple transforms of various objects. The game object's original start position can be used when the hammer is being thrown. We use a curve point so the game object would be able to curve back towards the player instead of in a linear fashion. We use audio source and audio clips to play correspondent sound files when the hammer is thrown and when the hammer is being recalled. The following snippet shows how the global variables are set up:

```
1     public Image crosshair;
2     public WeaponScript ws;
3     public Rigidbody hammer;
4     private Vector3 origLocPos;
5     private Vector3 origLocRot;
6     public Transform target, curve_point;
7     private Vector3 old_pos;
8     private bool isReturning = false;
9     private float time = 0.0f;
10    public Transform hand;
11    public Transform spine;
12    public Transform weapon;
13    public AudioSource audioSource;
14    public AudioClip hammerThrow;
15    public AudioClip hammerBack;
16    public float volume = 0.5f;
17
18    private Rigidbody temp;
19    int counter = 0;
20    public Vector3 ThrowBackForceVector;
21    bool hammerIsThrown = true;
22
23    [Header("Parameters")]
24    public float throwForce = 50;
```

Snippet 1: The global variables for the hammer script

The following snippet goes over different functions used for different purposes: ThrowHammer, ReturnHammer and ResetHammer. The ThrowHammer function makes the parent of the hammer null and not kinematic, which enables us to detach the hammer and later add force to the throw. Addforce is an inbuilt unity function to add force to an object. Forcemode.Impulse is added in conjunction with AddForce, so we can apply an instant force to the object so that the hammer can travel faster. AddTorque is added so the Forcemode.Impulse will be applied to the rigid body of the object. ReturnHammer function takes the old position of where the hammer was thrown from, in this case, the hand of the character, and adds velocity and turns Kinematic to true. ResetHammmer function resets the position of the hammer when it has reached the old position and enables the old position within its previous parent and its original position and rotation.

```
1     void ThrowHammer()
2     {
3         hammer.transform.parent = null;
4         hammer.isKinematic= false;
5         hammer.AddForce(Camera.main.transform.TransformDirection(Vector3.forward) *
              throwForce, ForceMode.Impulse);
6         hammer.AddTorque(hammer.transform.TransformDirection(Vector3.right) * 150,
              ForceMode.Impulse);
7     }
8     //Return Hammer
9     void ReturnHammer()
10    {
11        old_pos = hammer.position;
12        isReturning = true;
13        hammer.velocity = Vector3.zero;
14        hammer.isKinematic = true;
15    }
16    //Reset
17    void ResetHammer()
18    {
19        time = 0.0f;
20        isReturning = false;
21        hammerIsThrown = false;
22        weapon.parent = hand;
```

```
        hammer.transform.parent = hand;
        weapon.localEulerAngles = origLocRot;
        weapon.localPosition = origLocPos;
    }
```

Snippet 2: Functions for throwing and returning the hammer

The following snippet is using Bézier curve for calculating the return path of the hammer when it is being recalled back to the player. Bézier curve is a parametric curve and is used in computer graphics and other related fields [37]. For this particular project, a Quadratic Bézier curve is used to path trace and do linear interpolation for the calculations, where the hammer's path is curving around a game object before returning to the player. The formula can be seen as a function in Snippet 3.

```
Vector3 getBQCPoint(float t, Vector3 p0, Vector3 p1, Vector3 p2)
    {
        float u = 1 - t;
        float tt = t * t;
        float uu = u * u;
        Vector3 p = (uu * p0) + (2 * u * t * p1) + (tt * p2);
        return p;
    }
```

Snippet 3: Quadratic Bezier curve calculation

The following snippet covers how all the previous functions for the hammer is updated every frame in the game. This is done using a try catch block to ensure that the application does not cause an unhandled exception during the process. There are three main if statements for each action: throw, return and return path with reset for hammer position. For throw and return, we check if the hammer is either thrown or returning, which then executes either if statements when the conditions are met e.g. is the hammer thrown, and if not execute first if statement. When the hammer is returning to the player, we then utilize the Bézier curve function to calculate the time, old position, curve point and its target position; otherwise it resets the hammer. This code can be seen in Snippet 4.

```
void Update()
    {
        try
        {
            //Range
            if (Input.GetButtonUp("Fire1") && !hammerIsThrown)
            {
                audioSource.PlayOneShot(hammerThrow, volume);
                ThrowHammer();
                hammerIsThrown = true;
            }

            if (Input.GetButtonDown("Fire1") && hammerIsThrown && !isReturning)
            {
                audioSource.PlayOneShot(hammerBack, volume);
                ThrowBackForce();
                ReturnHammer();
                temp = null;
            }

            if (isReturning) //returning Calcs - Quadratic Bezier curves
            {
                if (time < 1.0f)
                {
                    hammer.position = getBQCPoint(time, old_pos,
                        curve_point.position, target.position);
                    hammer.rotation = Quaternion.Lerp(hammer.transform.rotation,
                        target.rotation, 50 * Time.deltaTime);
                    time += Time.deltaTime;
                }
                else
                {
                    ResetHammer();
                }
            }
        } catch (Exception e) {
            Debug.LogWarning(" thowable hammer exception " + e);
        }
    }
```

Snippet 4: Update method for firing and returning the hammer

5.2 Toon Shader

The toon shader, or known as cel-shading, is a rendering style designed to make 3D surfaces emulate 2D flat surfaces [35]. We use a standard shading model called Blinn-Phong and apply additional filters to achieve a toon look. The following subsection will describe and discuss five main components which are included in the shader: Directional Light, Ambient light, Specular reflection, Rim Lighting, and Shadows [50]. **Ambient light** represents the light that bounces off the surfaces of objects in the area, and it scatters in the atmosphere [50]. *smoothstep* is used to help maintain a sharp edge for the shader, so it does not look jagged. **Specular reflection** models the individual, distinct reflections made by light sources in the scene [50]. This reflection is view dependent, in that is affected by the angle that the surface is viewed at [50]. **Rim lighting** is the addition of illumination to the edges of an object to simulate reflected light and backlighting. This is optional but it will help the object's silhouette stand out among flat shaded surfaces. **Shadows** are added for the shader to cast and receive shadows from the directional light.

```
v2f vert (appdata v) //setting up world normals and view direction to set-up for calculations later in fragment shader
{
    v2f o;
    o.pos = UnityObjectToClipPos(v.vertex);
    o.viewDir = WorldSpaceViewDir(v.vertex);
    o.worldNormal = UnityObjectToWorldNormal(v.normal);
    o.uv = TRANSFORM_TEX(v.uv, _MainTex);
    TRANSFER_SHADOW(o)
    return o;
}
```

Snippet 5: Vertex shader code of the Toon shader.

In snippet 5, in the vertex function, we are getting the position, view direction, and world normals of the scene [50]. Afterwards, We are transforming the normal from object space to world space, as the light's direction is provided in world space [50]. With the world normals now available, we can compare the light's direction using the Dot Product. The dot product takes in two vectors (of any length) and returns a single number. When the vectors are parallel in the same direction and are unit vectors, the number will be 1. When they are perpendicular, it is 0. In snippet 6, we will calculate the light intensity with the dot product, and using dot product values for the specular intensity, rim lighting, shadows, and return the output with the ambient colour [50].

```
float4 frag (v2f i) : SV_Target
{
    float3 viewDir = normalize(i.viewDir);
    float4 sample = tex2D(_MainTex, i.uv);
    float3 normal = normalize(i.worldNormal);
    float3 halfVector = normalize(_WorldSpaceLightPos0 + viewDir);
    float NdotH = dot(normal, halfVector); //Dot product normals
    float NdotL = dot(_WorldSpaceLightPos0, normal); //Dot product of light direction based on world space
    float shadow = SHADOW_ATTENUATION(i); //macro that returns a value between 0 and 1, where 0 is no shadow and 1 is fully shadow
    float lightIntensity = smoothstep(0, 0.01, NdotL * shadow); //multiply with dot product light direction in world space
    float4 light = lightIntensity * _LightColor0; //then multiplied by the final output
    float specularIntensity = pow(NdotH * lightIntensity, _Glossiness * _Glossiness);
    float specularIntensitySmooth = smoothstep(0.005, 0.01, specularIntensity); //using smoothstep to "toonify" the reflection
    float4 specular = specularIntensitySmooth * _SpecularColor; //and then multiplied by the final output
    float4 rimDot = 1 - dot(viewDir, normal);
    float rimIntensity = rimDot * pow(NdotL, _RimThreshold); //Controls how far the rim of the surfaces will go out, and using pow function to scale the rim
    rimIntensity = smoothstep(_RimAmount - 0.01, _RimAmount + 0.01, rimIntensity);
    float4 rim = rimIntensity * _RimColor; //then multiply by the final output
    return _Color * sample * (_AmbientColor + light + specular + rimDot + rim);
}
```

Snippet 6: Fragment shader code of the Toon shader.

5.3 Hammer Dialog script

In the game, there are two different dialogues, those who are seen as the main that include introductions of different areas and gameplay tips, and those that are played when the player reached subjective landmarks which are surrounded by flowers, where a druid like VFX are played those are

referred to as nature tracks. They use the same function to be a player but with a different list of booleans, they both have local booleans, that are assigned through the class, and an equally long list that is dependent on external booleans that are activated through gameplay. To give the player some breathing room between the different dialogs fx between the quest introduction and gameplay tips the main dialogs have a delay of 1.5 seconds and the nature dialogs has a delay of 1 second see the function below.

```
1   void FixedUpdate(){
2       counter++;
3       if (counter % Mathf.Round((1.5f) / Time.fixedDeltaTime) == 0){
4           if (!sound.isPlaying && i < audioTrack.Count){
5               SetCondition(audioTrack, sentences, mainDialogExternalBoolList,
                    mainDialogLocalBoolList, true, i, j);
6           }
7       }
8       if (counter % Mathf.Round((1f) / Time.fixedDeltaTime) == 0){
9           if (!sound.isPlaying && ni < natureTrack.Count){
10              SetCondition(natureTrack, natureSentences,
                    natureDialogExternalBoolList, natureDialogLocalBoolList, false,
                    ni, nj);
11          }
12      }
13  }
```

Snippet 7: Dialog script update delay

The function setCondition was created to avoid to many if statements that required different conditions, their for it require two sets of booleans. If the condition is met, a function playSound is called, and local booleans are updated.

```
1    void SetCondition(List<AudioClip> track, string[] txtDialog,List<bool>
         externalBool,    List<bool> myLocalBools, bool main, int myi, int myj) {
2           if (externalBool[myj] && !myLocalBools[myj] && !sound.isPlaying){
3               textComponent.text = "";
4               playSound(track, txtDialog,myi);
5               myLocalBools[myj] = true;
6               setIncrements(main);
7           }
8   }
```

Snippet 8: Dialog script start

The function below shows the function playSound which plays the dialog, it also calls the function startDialog which generate the subtitles with one letter at the time see line 16 - 25.
The way it works is that for each letter there are in the string is added to the existing string that is shown with a delay based on the textSpeed which is 0.1 seconds.

```
1   void playSound(List<AudioClip> track, string[] txtDialog, int i_){
2       if (!sound.isPlaying){
3           isPlaying = false;
4           StopAllCoroutines();
5           sound.Stop();
6       }
7       lastDialog = txtDialog[i_];
8       if (!isPlaying){
9           isPlaying = true;
10          dialogueBox.SetActive(true);
11          StartDialogue(txtDialog,i_);
12          sound.PlayOneShot(track[i_]);
13          sound.Play();
14      }
15  }
16  void StartDialogue(string[] txtDialog, int i_){
17      StartCoroutine(TypeLine(txtDialog, i_));
18  }
19  IEnumerator TypeLine(string [] txtDialog,int i_){
20      foreach (char c in txtDialog[i_].ToCharArray())
21      {
22          textComponent.text += c;
23          yield return new WaitForSeconds(textSpeed);
24      }
25  }
26  void showLastDialog() {
27      if (Input.GetKey(KeyCode.Q)){
28          if (!sound.isPlaying) {
29              Qbutton.SetActive(false);
30              dialogueBox.SetActive(true);
31              textComponent.text = lastDialog;
32              showDialog = true;
33              qPressed = true;
34          }
35      }else {
```

```
36              showDialog = false;
37          }
38      }
```

Snippet 9: Dialog script start

The function showLastDialog on line 26-37 shows the last dialog that have been played if the player presses 'Q' to help the player if they have forgotten their objective. The string lastDialog is assigned to the dialog on line 7.

5.4 Read Json

The scripts used to create the player position maps through a JSON file were originally also created by the research team in a previous project [35]. While the script that writes the JSON file remained the same, a few changes were implemented for the script that read the JSON file and changed the colors of the high concentrations of the player position map see section 5.5.
Much data was expected to be collected from the test therefor it was desided to have three list of vector3s to hold the player positions one from each overall quest see section **??**, therefore making it less demanding for the computer to generate all the positions was a priority, therefor a new class was added to the script with the purpose of this class was to remove all the positions that were identical to each other and count how many identical positions there were. From line 1 to 4 is an example of how the class is used to set up the new list, what is important there is on line 2 where the Q1positions list is first sorted based on their z values, the z coordinate was chosen due to the starting position of the player.

```
1  /*
2          Q1positions = Q1positions.OrderBy(v => v.z).ToList();
3          q1List.setLists(Q1positions);
4  */
5
6  public class DublicantFree {
7      public List<Vector3> positions;
8      public List<int> dublicants;
9      public int dublicantCounter = 1;
10     public int count { get; set; }
11     public DublicantFree() {
12         positions = new List<Vector3>();
13         dublicants = new List<int>();
14     }
15     public void setLists( List<Vector3> orgList) {
16         for (int i = 0; i < orgList.Count; i++){
17             if (i!=0) {
18                 if (orgList[i - 1] == orgList[i]) {
19                     dublicantCounter++;
20                 }
21             }
22             positions.Add(orgList[i]);
23             dublicants.Add(dublicantCounter);
24             dublicantCounter = 1;
25         }
26          removeDublicants();
27     }
28     private void removeDublicants() {
29         for (int i =1; i < positions.Count; i++) {
30             if (positions[i - 1] == positions[i]){
31                 positions.RemoveAt(i);
32                 dublicants.RemoveAt(i);
33             }
34         }
35         count = positions.Count;
36     }
37 }
```

Snippet 10: DublicantFree class

In addition to that three vector3 lists was also needed to be able to generate the positions through iterations, and adding the duplicated values to the positions that were removed,on line 44-54 can it be seen where the list gains their values.
The nested for loop in the start function on lines 11-15 goes through each of the participants and each of the participants' quest indexes from the JSON script. The player positions were stored as a string in the JSON file so, in the function GetPlayerPositionsFromJson, it first isolates the x,y, and z coordinates and then converts them to floats and are then added to the corresponding list of player positions depending on the quest the participant was currently playing as was mentioned earlier.

```
1      private string pathA = "/Json/MergedGroupA.json";
```

```
2       private string pathB = "/Json/MergedGroupB.json";
3       private string path
4       void Start(){
5            path = SceneManager.GetActiveScene().name == "Sector_Model" ? pathB : pathA;
6           Q1positions = new List<Vector3>();
7           Q2positions = new List<Vector3>();
8           Q3positions = new List<Vector3>();
9           jsonString = File.ReadAllText(Application.dataPath + path);
10          itemData = JsonMapper.ToObject(jsonString);
11          for (int k = 0; k < itemData[0].Count; k++){
12              for (int i = 0; i < itemData[0][0][0].Count; i++){
13                  try {GetPlayerPositionsFromJson(k, i);} catch (Exception e) { }
14              }
15          }
16          Q1positions = Q1positions.OrderBy(v => v.z).ToList();
17          Q2positions = Q2positions.OrderBy(v => v.z).ToList();
18          Q3positions = Q3positions.OrderBy(v => v.z).ToList();
19          q1List.setLists(Q1positions);
20          q2List.setLists(Q2positions);
21          q3List.setLists(Q3positions);}
22      }
23      void GetPlayerPositionsFromJson(int participatNumber,int QuestNumber){
24          float x = 0;
25          float y = 0;
26          float z = 0;
27          for (int i = 0; i < itemData[0][participatNumber][0][QuestNumber]
28              ["Player_Positions"].Count; i++){
29
30              string xString = itemData[0][participatNumber][0][QuestNumber]
31                  ["Player_Positions"][i].ToString().Split(',')[0].
32                  Trim('(');
33              string yString = itemData[0][participatNumber][0][QuestNumber]
34                  ["Player_Positions"][i].ToString().Split(',')[1];
35
36              int startZ = itemData[0][participatNumber][0][QuestNumber]
37                  ["Player_Positions"][i].ToString().IndexOf
38                  (itemData[0][participatNumber][0][QuestNumber]
39                  ["Player_Positions"][i].ToString().Split(',')[2]);
40              int endZ = itemData[0][participatNumber][0][QuestNumber]
41                  ["Player_Positions"][i].ToString().IndexOf(')');
42
43              string zString = itemData[0][participatNumber][0][QuestNumber]
44                  ["Player_Positions"][i].ToString().Substring(startZ, endZ - startZ);
45
46              x = float.Parse(xString);
47              y = float.Parse(yString);
48              z = float.Parse(zString);
49
50              if (QuestNumber == 0) {
51                  Q1positions.Add( new Vector3(x, y, z));
52              }
53              if (QuestNumber == 1)
54              {
55                  Q2positions.Add(new Vector3(x, y, z));
56              }
57              if (QuestNumber == 2)
58              {
59                  Q3positions.Add(new Vector3(x, y, z));
60              }
61          }
62      }
```

Snippet 11: ReadJson script

On lines 4 to 19 it can be seen that the map is being generated at 1-sec intervals. The function CreaHeatMap creates a primitive time sphere where the positions are from the JSON script and on line 30 it can be seen where the value from the amount positions that shared the same position is being added to the generated objects.

```
1       private int seconds = 1;
2       private void FixedUpdate(){
3           counter++;
4           if (counter % Mathf.Round(seconds / Time.fixedDeltaTime) == 0 && seconds<4){
5               if (seconds ==1) {
6                   for (int i = 0; i < q1List.count; i++){
7                       CreateHeatMap(i, q1List, 1);
8                   }
9               }
10              if (seconds ==2) {
11                  for (int j = 0; j < q2List.count; j++){
12                      CreateHeatMap(j, q2List, 2);
13                  }
14              }
15              if (seconds ==3) {
16                  for (int k = 0; k < q3List.count; k++){
```

```
                    CreateHeatMap(k, q3List, 3);
                }
            }
            seconds++;
        }
    }
    void CreateHeatMap(int posIndex,DublicantFree df, int quest){

        GameObject sphere = GameObject.CreatePrimitive(PrimitiveType.Sphere);
        meshrender = sphere.GetComponent<MeshRenderer>();
        col = sphere.GetComponent<SphereCollider>();
        sphere.AddComponent<ChangeColor>();
        sphere.GetComponent<ChangeColor>().questNR = quest;
        sphere.GetComponent<ChangeColor>().dublicants = df.dublicants[posIndex];
        sphere.AddComponent<Rigidbody>();
        sphere.GetComponent<Rigidbody>().isKinematic = true;
        sphere.tag = "Positions";
        sphere.name ="Q"+quest+ "pos" + posIndex;
        col.isTrigger = true;
        sphere.transform.position = df.positions[posIndex];
        sphere.transform.localScale = new Vector3(0.75f, 0.5f, 0.75f);
        meshrender.material = mat[0];
        if (quest == 1) {
            sphere.transform.SetParent(Q1Parent);
        } else if (quest == 2) {
            sphere.transform.SetParent(Q2Parent);
        } else if (quest == 3) {
            sphere.transform.SetParent(Q3Parent);
        }
    }
```

Snippet 12: ReadJson script

5.5 Change Color

The change color script also originates from the research team earlier projects [35] however the different color sphere has been changed, to make it easier for the research team to analyse the data, each quest with have a main color red, green and blue respectivly, however if there is a to high consentration within an area it will become white. In addtion to the dublicant values as mentioned ealier see section 5.4, their value will also change if their collider is in collison with a similar collider. for every 10s collision or shared postion the objects has they will gain a high consentrain of the color quest they are a part of as can bee seen below

```
      private void OnTriggerEnter(Collider other){
        if (other.name.Contains("pos")){
            neighboor++;
        }
    }
   public void quest(int nr, byte myC ,byte notMyC, byte notMyC2, byte t) {
        // some of the code has been cut out of this snippet
            else if (counter >= 80 && counter < 90) {
                notMyC = 200;
                notMyC2 = 200;
                t= 175;
            } else if (counter >= 100 && counter < 110) {
                notMyC = 225;
                notMyC2 = 225;
                t= 175;
            } else if (counter >= 100 && counter < 110) {
                notMyC = 250;
                notMyC2 = 250;
                t= 175;
            }else {
                notMyC = 255;
                notMyC2 = 255;
                t= 175;
            }
        if (dublicants>10) { t = (byte)(t + dublicants); }
        if(nr==1){
            mat.SetColor("_Color", new Color32(myC, notMyC, notMyC2, t));
        } else if (nr == 2) {
            mat.SetColor("_Color", new Color32(notMyC2, myC, notMyC2, t));
        } else if (nr==3) {
            mat.SetColor("_Color", new Color32(notMyC2, notMyC2, myC, t));
        }
    }
    void ChangeColorPrSharedPos(){
        counter = (neighboor+ dublicants);
        quest(questNR, red, green, blue, transparentsy);
    }
```

Snippet 13: Change color script

6 Findings

41 participants were gathered for the evaluation of this study (Mean age = 26,63, SD = 3,533, Range = 21-38). The participants were university students, with 28 males, 11 females and 2 non binary. All participants has categorized themselves with various motivation models when playing games: 3 in action, 7 in social, 3 in mastery, 6 in achievement, 14 in immersion, 8 and in creativity. All participants were given informed consent and were informed that they could withdraw from the study at any time during the test. All participants were assigned with anonymous ID numbers, and all data were labelled with these ID numbers. 41 participants were recruited through convenience sampling via Facebook, Discord, SurveyCircle and on AAU CPH campus. As some participants were recruited through the researchers social network, there carries some social bias from the participants, as they are either students of the same study or acquaintances with the some of the researchers in this study.

Condition	**Sample size**	**Male**	**Female**	**Non Binary**
Control	20	13	6	1
Experimental	21	15	5	1

Table 1: Gender distribution

6.1 Quantitative data

The answers from the control and experimental groups regarding perceived wayfinding were compared between each group to see whether there is a significant difference between the different game layouts. Since the data samples from the groups are independent from each other, the data is ordinal and the $H1$ from section 3: ("There is a significant difference between sector layout and nuclei layout can affect a player's perceived wayfinding in a game.") is searching for any significant difference, the Mann-Whitney test was used as the gathered data was non-parametric.

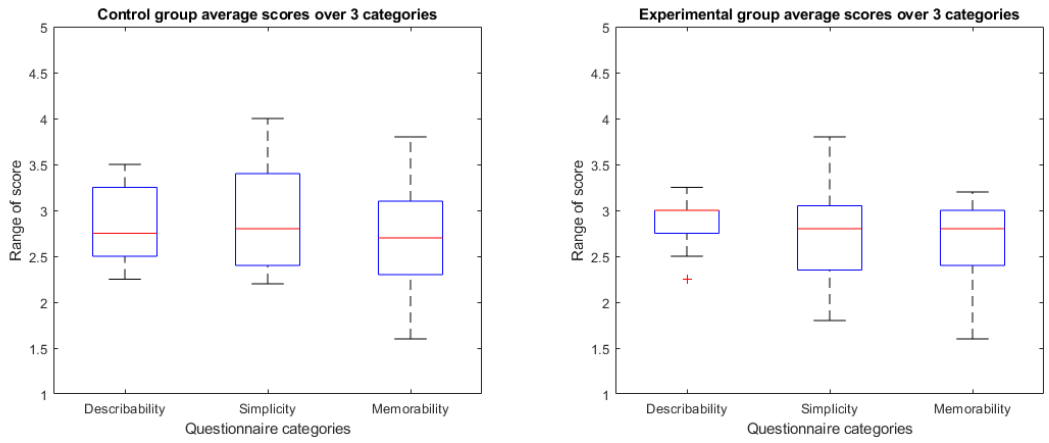
	Control	**Experimental**
Numerosity	14	14
Sum of Rank W	222	184
Mean Rank	15.857	13.142
Test Variable U	79	117

SD	**Z**	**P value one tail**	**P value two tails**
21.743	0.850	0.197	0.394

Table 2: Results from Mann-Whitney U Test

The Mann-Whitney test indicated that the perceived wayfinding of players was not significantly different between the participant from the control group (Mean Rank = 15.857) and the experimental group (Mean Rank = 13.142), p = 0.394, therefore we fail to reject the null hypothesis from section 3 ("There is no significant difference between sector layout and nuclei layout can affect a player's perceived wayfinding in a game.").

Next, the data of the average scores of each category for each group was converted to box plots. Both box plots indicates the perceived wayfinding for player's for each category. We can see in control group (a) that the median are very similar for each category. The experimental group (b) were also very similar for each category, which further proves that there were no significant difference between each group.



(a) (b)

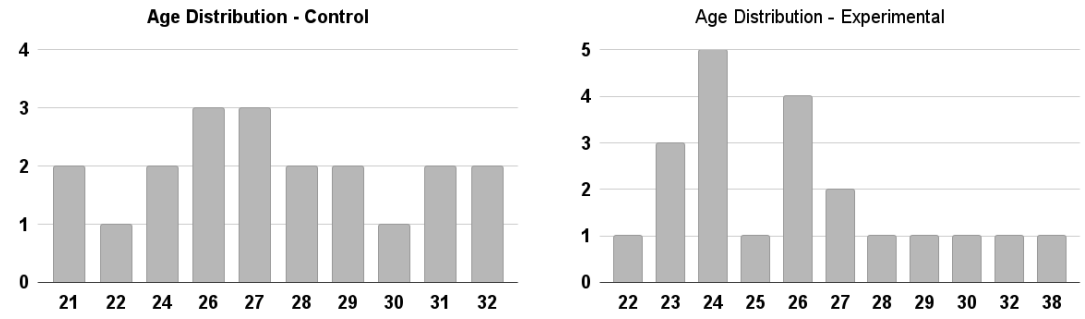
Figure 35: Control (a) and experimental (b) groups average score over 3 categories from the questionnaire. Control had n = 20, and Experimental n = 21 for a total of n = 41.

Cronbach alpha was used to test the internal consistency and reliability of the questionnaire which was constructed in section 3. The result from the Cronbach Alpha test gave us a = 0.5352, which indicates that the questionnaire has poor consistency and low reliability. This means, that the questionnaire itself needs to be improved for further research to make it more consistent and reliable.

6.1.1 Histograms

The following section shows the information regarding the participants age distribution, player motivation model distribution, average number of hours playing games per week, which layout they thought they were in, and time players spent inside the game.

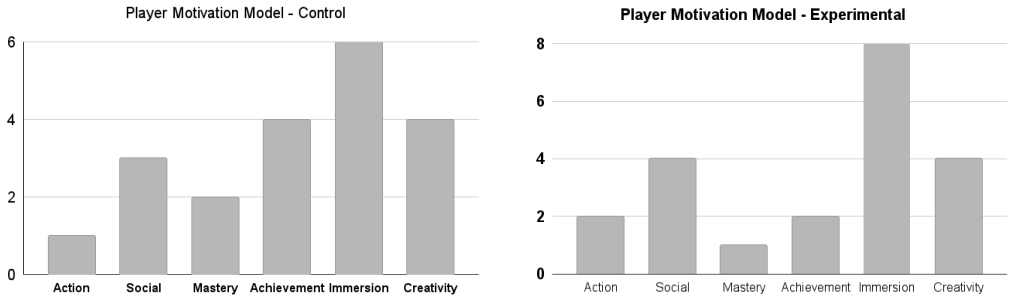
The age distribution between each group are shown in figure 36. Control group (a) has a mean age of 27.05, SD of 3.339 and range from 21-32. Experimental group (b) has a mean age of 26.238, SD of 3.700 and range from 22-38.



(a) (b)

Figure 36: Control (a) and experimental (b) age distribution. Control had n = 20, and Experimental n = 21 for a total of n = 41.

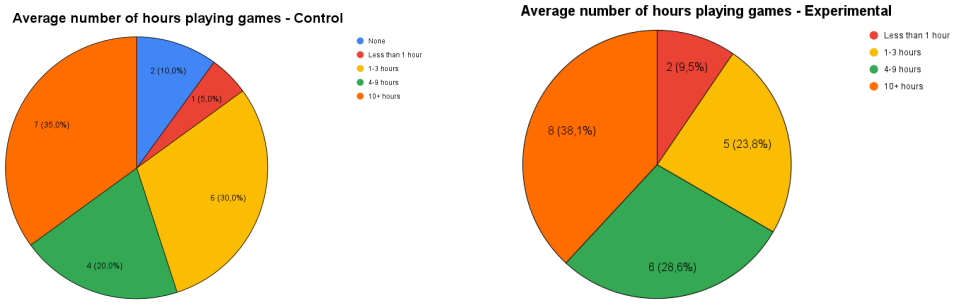
The player motivation model between each group are shown in figure 37. Control group (a) has 1 in action, 3 in social, 2 in mastery, 4 in achievement, 6 in immersion, and 4 in creativity. Experimental group (b) has 2 in action, 4 in social, 1 in mastery, 2 in achievement, 8 in immersion, and 4 in creativity.



(a) (b)

Figure 37: Control (a) and experimental (b) player motivation model. Control had n = 20, and Experimental n = 21 for a total of n = 41.

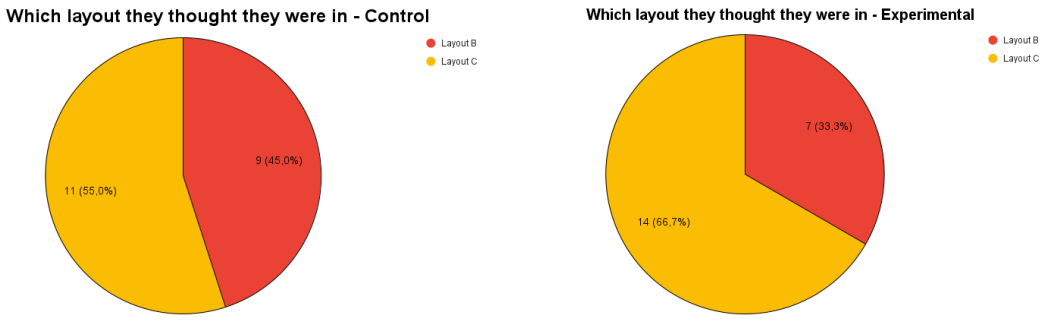
The average number of hours spent playing games per week are shown in figure 38. Control group (a) has 2 with no hours spent on games per week, 1 with less than 1 hour, 6 with 1-3 hours , 4 with 4-9 hours, and 7 with 10+ hours. Experimental group (b) has 2 with less than 1 hour per week, 5 with 1-3 hours, 6 with 4-9 hours, 8 with 10+ hours.



(a) (b)

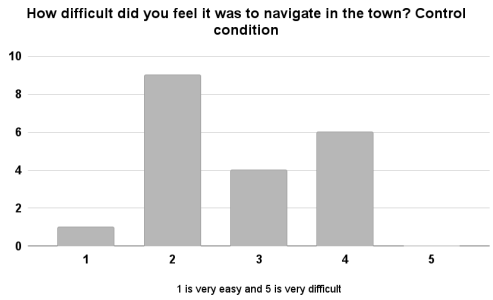
Figure 38: Control (a) and experimental (b) average number of hours playing games per week. Control had n = 20, and Experimental n = 21 for a total of n = 41.

The results of players guessing which layout they thought they were in are shown in figure 39. Control group (a) has 9 (45%) people guessed they were in layout B, and 11 (55%) people guessed they were in layout C. Experimental group (b) has 7 (33,3%) people guessed they were in layout B, and 14 (66,7%) people guessed they were in layout C. The control group had a 55% accuracy with the correct layout, while the experimental group had a 33,3% accuracy with the correct layout.



(a) (b)

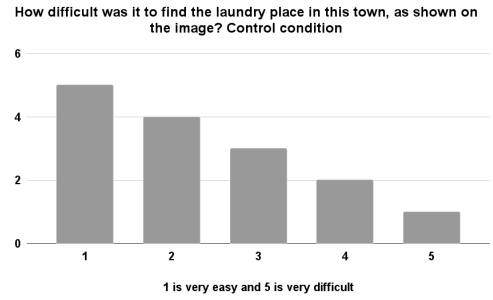
Figure 39: Control (a) and experimental (b) which layout they thought they were in. Control had n = 20, and Experimental n = 21 for a total of n = 41.



(a)

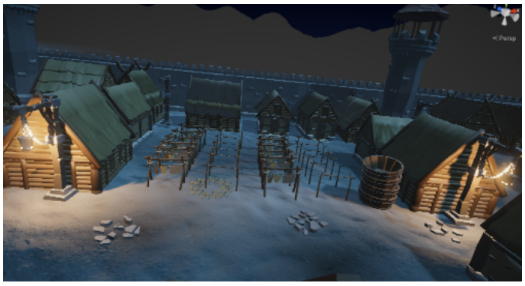
(b)

Figure 40: Control (a) and experimental (b) of how difficult they felt it was to navigate in the town where 1 is very easy and 5 is very difficult. Control had n = 20, and Experimental n = 21 for a total of n = 41.



(a)

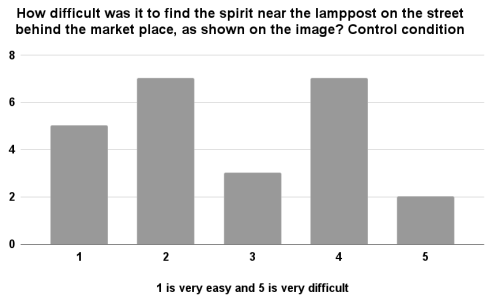
(b)



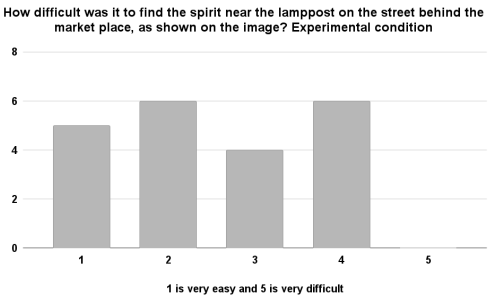
(c)

(d)

Figure 41: Control (a) were asked for laundry place (c) and experimental (b) were asked for the laundry place (d) of how difficult it was to find the laundry place in town where 1 is very easy and 5 is very difficult . Control had n = 20, and Experimental n = 21 for a total of n = 41.



(a)



(b)

(c)

(d)

Figure 42: Control (a) and experimental (b) how difficult it was to find spirits around the town where 1 is very easy and 5 is very difficult. Control had n = 20, and Experimental n = 21 for a total of n = 41.

The following table in table 3 shows in the difference in minutes and seconds for each quest and total time players spent inside the game between each group.

	Quest 1	**Quest 2**	**Quest 3**	**Total time**
Control	3:32 min	3:44 min	1:01 min	8:01 min
Experimental	3:40 min	2:58 min	1:50 min	8:27 min

Table 3: Average time in minutes for all participants in each condition, one outlier from the control group was removed from the data, the outlier used 28 min to complete the game

6.1.2 Qualitative comments

	Total amount of places	**Average amount**	**Sample size**
Control	112	5.6	20
Experimental	90	4.2	21

Table 4: The first column in the table shows the total amount of places the participants answered to the question "How many different areas of the town would you have drawn, and what would you have called them?" for the control and experimental group. The second column shows the average amount of places the participants mentioned for each group.

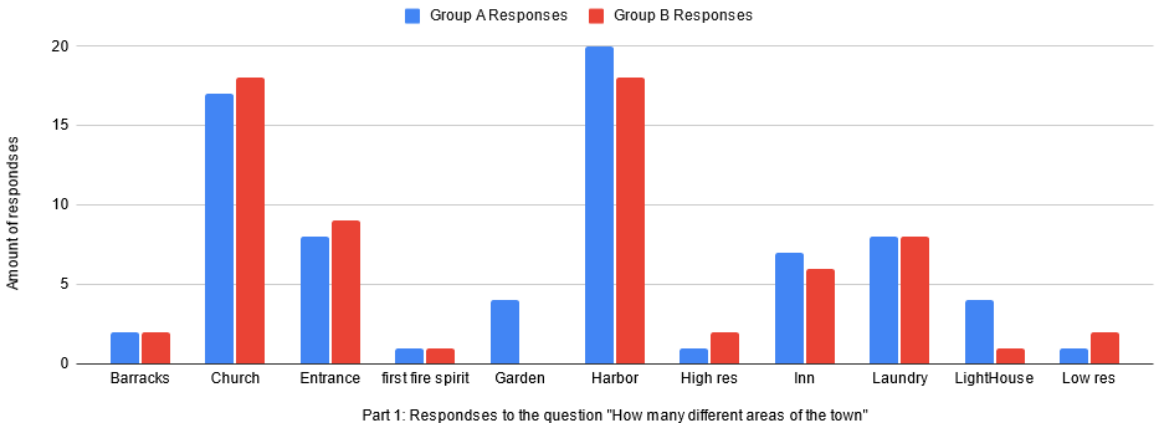


Figure 43: This figure shows the first part of the answers the participants answered to the question "How many different areas of the town would you have drawn, and what would you have called them?", where blue is answers from group A and red is the answers from group B

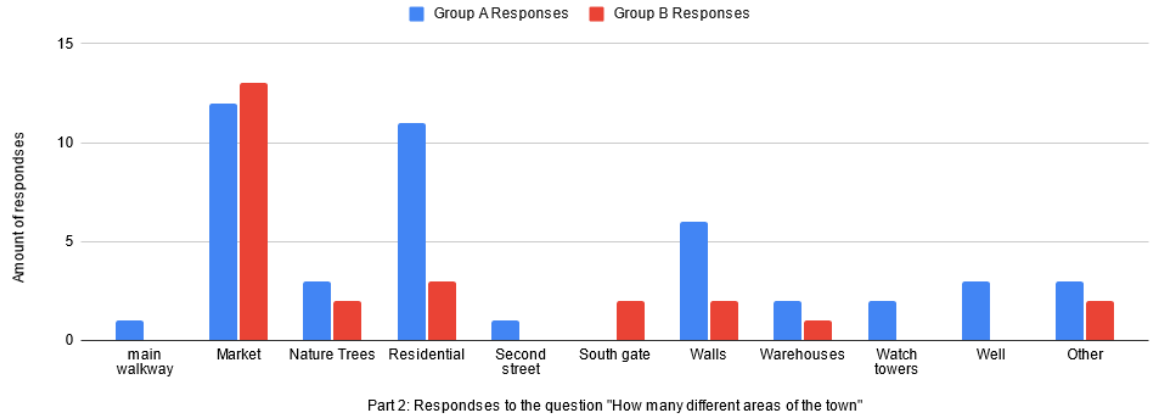


Figure 44: This figure shows the second part of the answers the participants answered to the question "How many different areas of the town would you have drawn, and what would you have called them?", where blue is answers from group A and red is the answers from group B

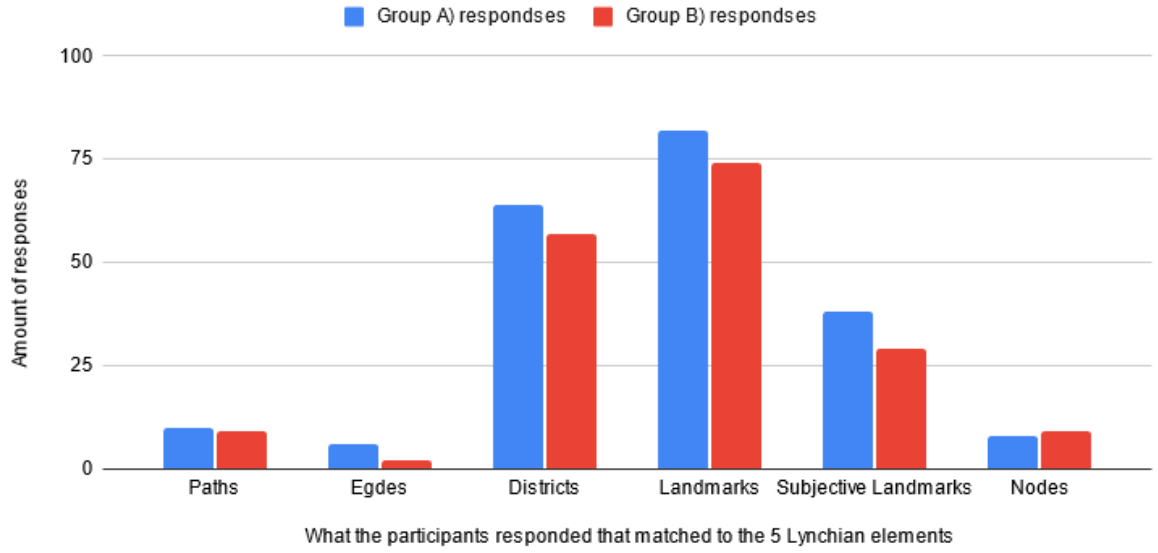


Figure 45: This figure shows the number of responses from the question "How many different areas of the town would you have drawn, and what would you have called them?" where the responses would fit into the five Lynchian elements, where blue is answers from group A and red is the answers from group B

6.2 Interview data

From the test, we got a total of 6 participants (3 from each condition) for interviews to get more in-depth qualitative data about the participants overall experience of the game through a semi-structured interview. This would give us more insights on the difference between control and experimental group from their responses. Both groups were able to identify the large landmarks such as Church and Harbour, but felt the rest of the houses were too uniform and similar and made it harder to differentiate when answering the question "Could you feel that each area/district had its own feel to it?":

> "The streets looked very uniform and hard to differentiate. The town was not very exciting for me to explore." (Male, 26, ID04, Social) from control group.

> "Most of the main places such as a church, the docks, and the laundry were easy to differentiate, but the streets with the houses were very similar to each other and could get lost in the town."(Female, 25, ID02, Creativity) from experimental group.

Participants from the control condition had a hard time to find the market place compared to participants from experimental condition when asked the question "Was there at any point during the game you felt lost?":

> "I mostly followed the road lines and lights to get around and did not pay much attention to the buildings. If the fire spirits were not there, I would have been lost." (Male, 26, ID04, Social) from control group.

> "There was one point where I was confused about where the marketplace was, so I wandered around to explore around a bit." (Male, 31, ID06, Creativity) from the control group

Another participant from control group mentions the colour had an affect on how they could not differentiate buildings and props in the game:

> "The colours were very flat, and there were not a lot of variations as there were a lot of the same props, but I can see that it is a specific art style, so it did not bother me that much." (Male, 27, ID01, Immersion) from control group.

When asked the question "What do you remember about the game's story?", 2 participants from control group gave interesting feedback regarding the story of the game:

> "I wanted to see more after what I just played as I saw that there was a boss fight." (Male, 27, ID01, Immersion) from control group.

> "The story was more a vehicle for carrying the game's theme, so the theme was more the main focus than the story." (Male, 26, ID04, Social) from control group.

One participant from experimental group when asked the same question as before gave a different response as soon as they entered the game:

> "All I wanted to do when I started this game was run around, jump and throw this hammer around, but then I got told what to do, which made me sad." (Male, 23, ID03, Action) from experimental group.

One participant from experimental group when asked the question "Could you describe your mood throughout the game?" gave a interesting response regarding what could be improved in the game:

> "I was feeling cold and darkness from the environment itself... ""...I felt like it was a ghost town and wanted more NPCs around to talk to." (Female, 25, ID02, Creativity) from experimental group."

6.3 Player position maps

This section will show all of the player position maps that were gathered from the data from the JSON file. First, all the player position maps from the nuclei will be shown, first a map of the overall movement of the participants, later the player position maps will focus on each quest. After that, the player position maps from the sector condition will be shown, which will be following the same order of figures as with the nuclei player position maps. The section will end with player position maps from the participants who had responded that they were mainly motivated to play games through immersion, because the immersion category was the one that was most popular from the respondents. Those figures will show some interesting behavior from those participants in the game.

6.3.1 Nuclei map

Here will the player positions maps will be shown from the participants who played in the nuclei condition.

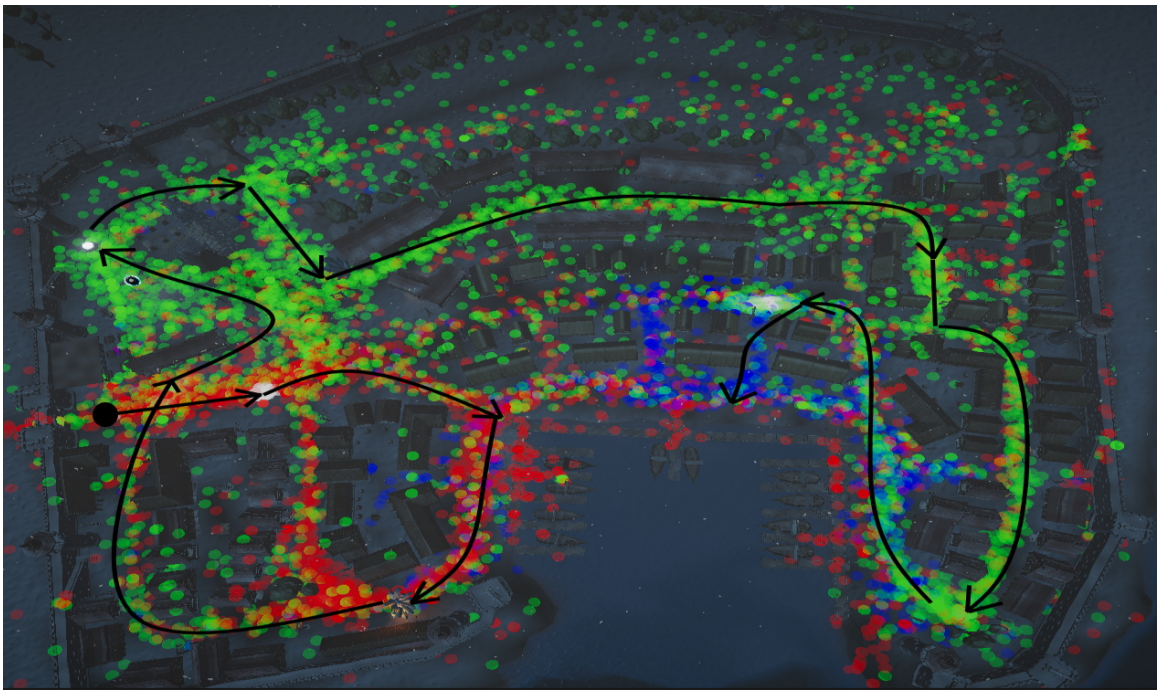


Figure 46: This figure shows all the positions the participants took within the town, in the multiple nuclei condition. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. Red shows the positions the participants were on doing while the first quest sequence was active. Green shows the positions the participants were in while the second quest sequence was active. Blue shows the positions the participants were in while the third quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

Figure 47: This figure shows the positions where the participants were in the town doing the first quest sequences. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. The Cyan spheres show the path the fire spirit takes after it has been freed. Red shows the positions the participants were on doing while the first quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

Figure 48: This figure shows where there was the highest concentration of participants doing the first quest sequence. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. The blue circles shows the positions the participant needs to search for. The Yellow circles shows quest objectives the participant needs to destroy. The Cyan spheres show the path the fire spirit takes after it has been freed. Red shows the positions the participants were on doing while the first quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

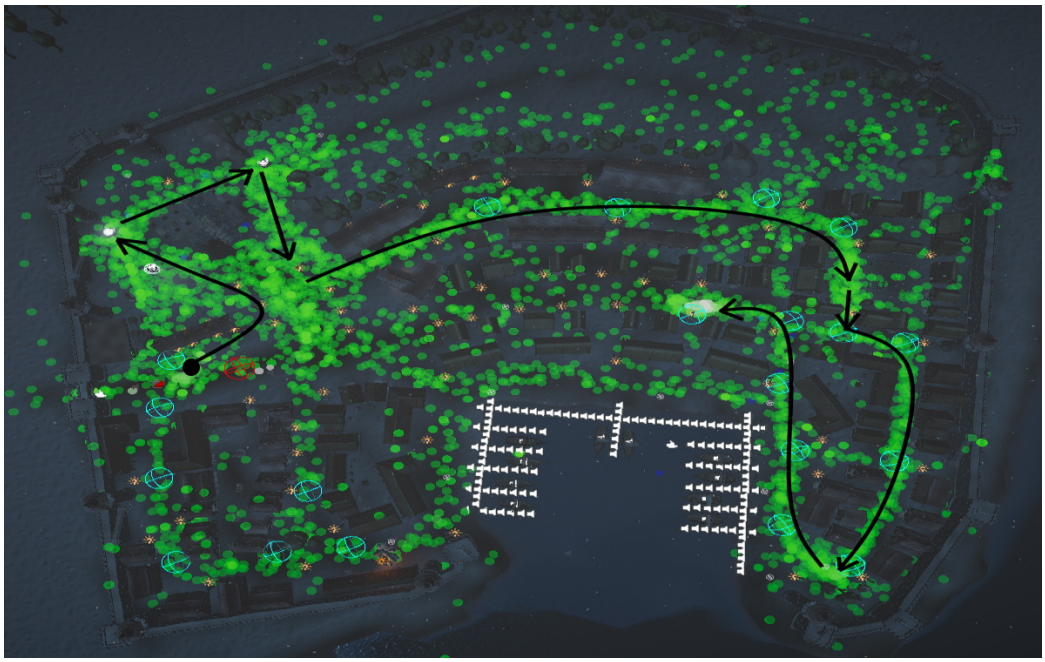


Figure 49: This figure shows the participants' position in the town while the second quest was active. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. The Cyan spheres show the path the fire spirit takes after it has been freed. Green shows the positions the participants were in while the second quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

Figure 50: This figure shows the participants' position at the start of the second quest sequence until the participants have freed the fire spirit. The black dot shows where the participants starts the game. The Yellow circles shows quest objectives the participant needs interact with of destroy. Green shows the positions the participants were in while the second quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions that are

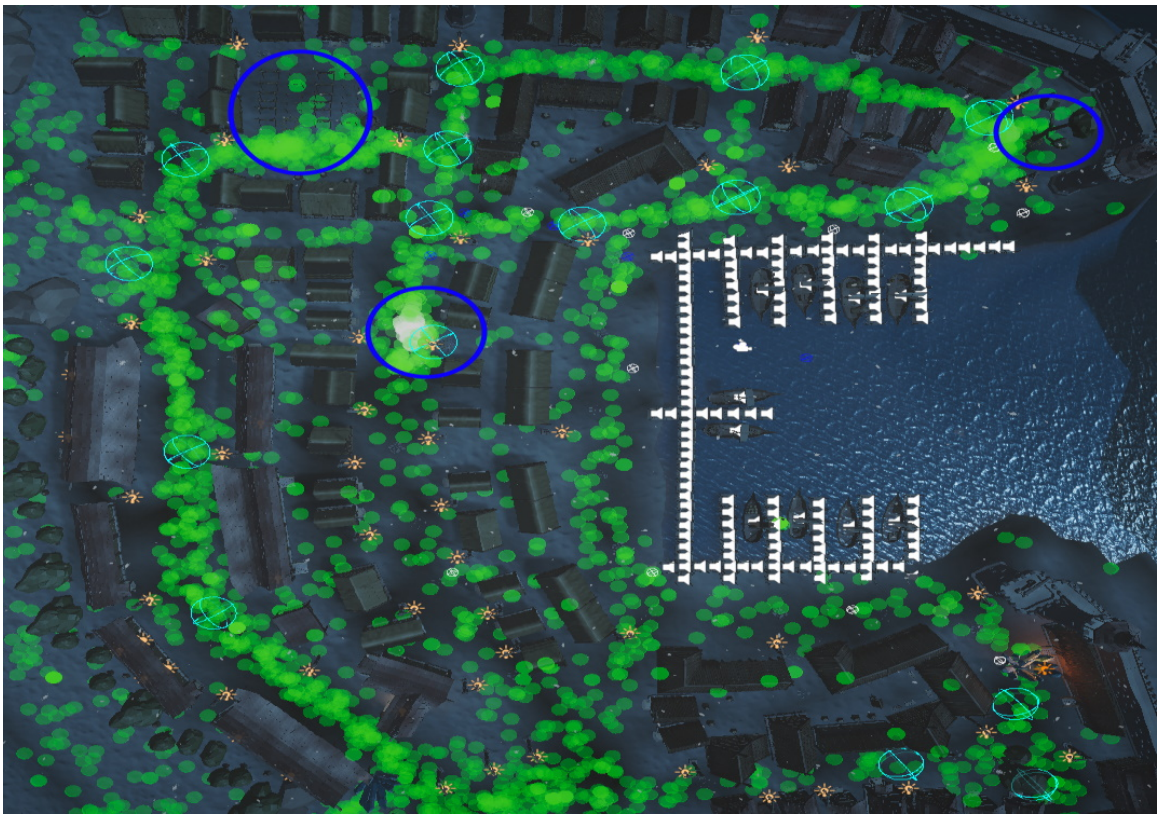


Figure 51: This figure shows the participants' position in the second quest sequence, where the participants are searching for a laundry place, the tree, and the lamppost on the street between the marketplace and the harbor which is indicated with the ring. The blue circles shows the positions the participant needs to search for. The Cyan spheres show the path the fire spirit is moving through. Green shows the positions the participants were in while the second quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions that are

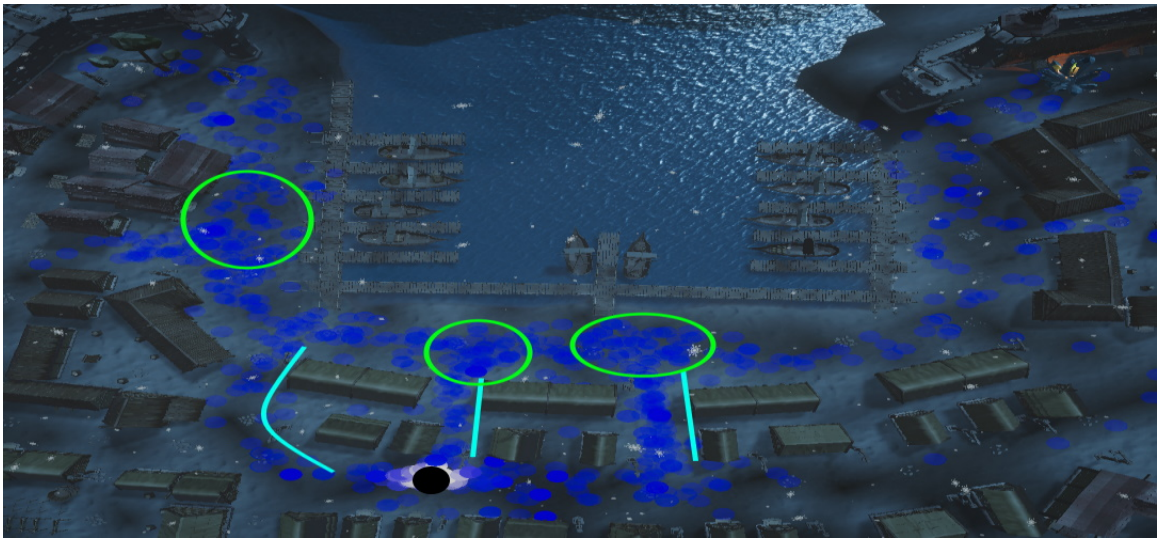


Figure 52: This figure shows the participants' position doing the third quest where they have to defeat a ship in the harbor. The black dot shows where the participants starts the game. The cyan colored line shows the direction where the camera moves through doing the cut scene, where the boss is introduced. The green circles shows the highest concentration of the players positions. Blue shows the positions the participants were in while the third quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

6.3.2 Sector map

Here will the player positions maps will be shown from the participants who played in the sector condition.

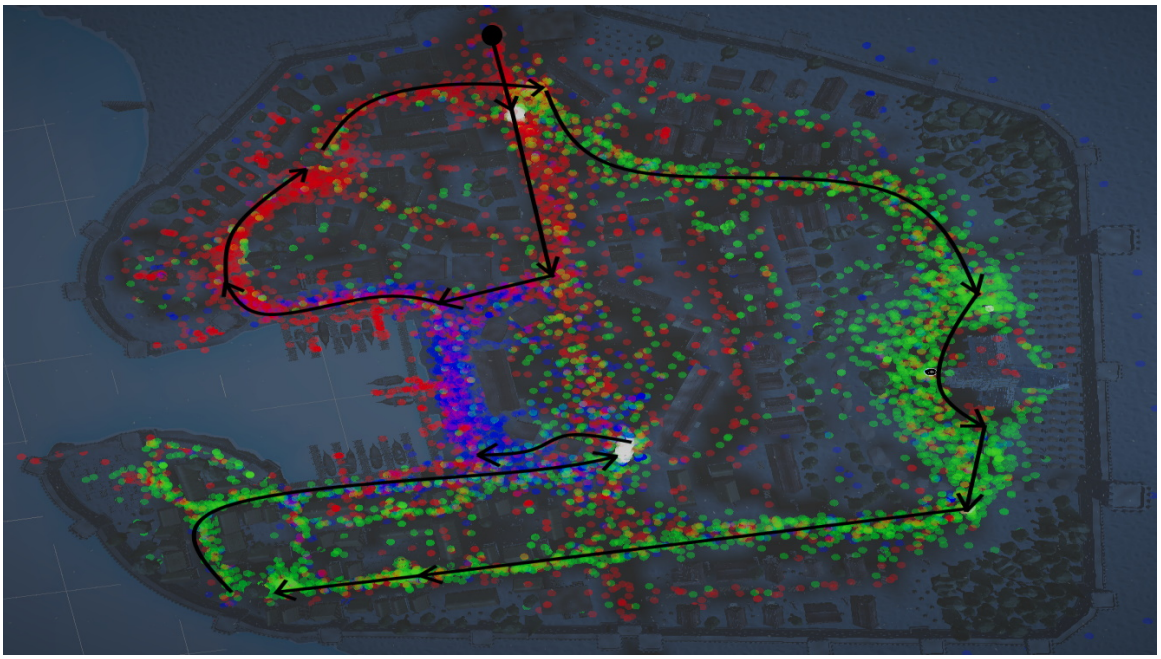


Figure 53: This figure shows all the positions the participants took within the town, in the Sector model condition. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. Red shows the positions the participants were on doing while the first quest sequence was active. Green shows the positions the participants were in while the second quest sequence was active. Blue shows the positions the participants were in while the third quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

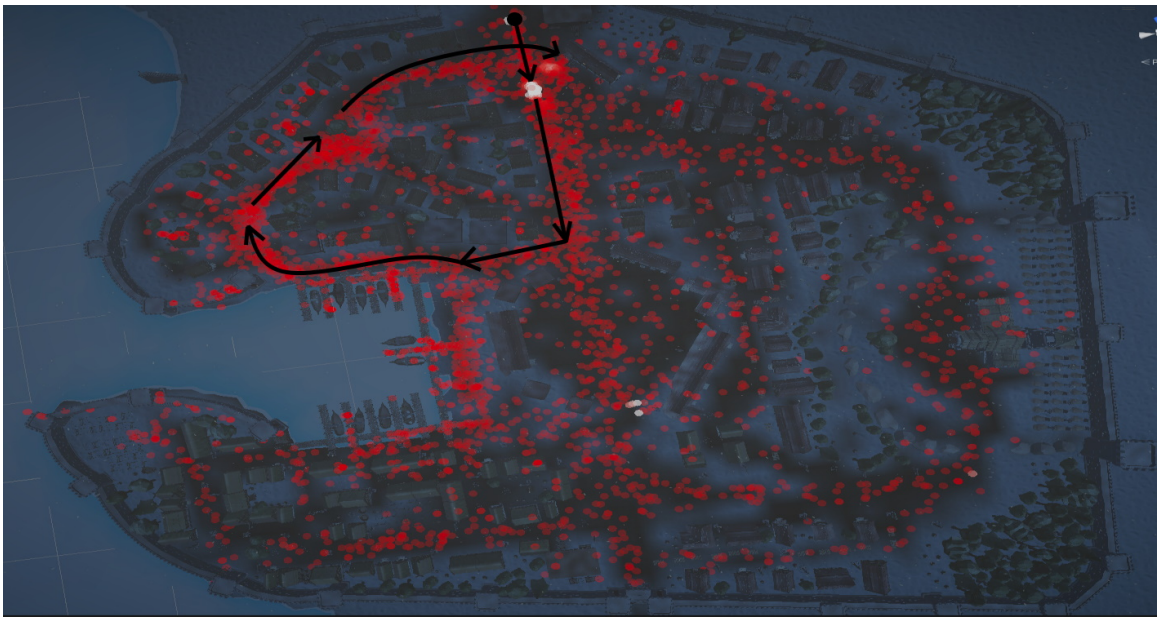


Figure 54: This figure shows the positions where the participants were in the town doing the first quest sequences. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. Red shows the positions the participants were on doing while the first quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

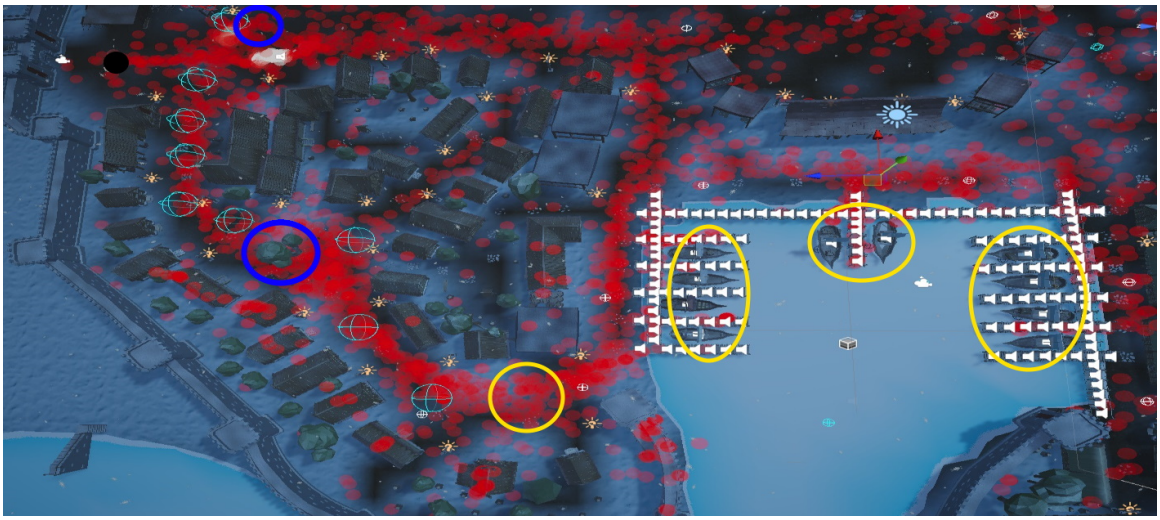


Figure 55: This figure shows where there was the highest concentration of participants doing the first quest sequence. The black dot shows where the participants starts the game. The blue circles shows the positions the participant needs to search for. The Yellow circles shows quest objectives the participant needs interact with of destroy. The Cyan spheres show the path the fire spirit takes after it has been freed. Red shows the positions the participants were on doing while the first quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.

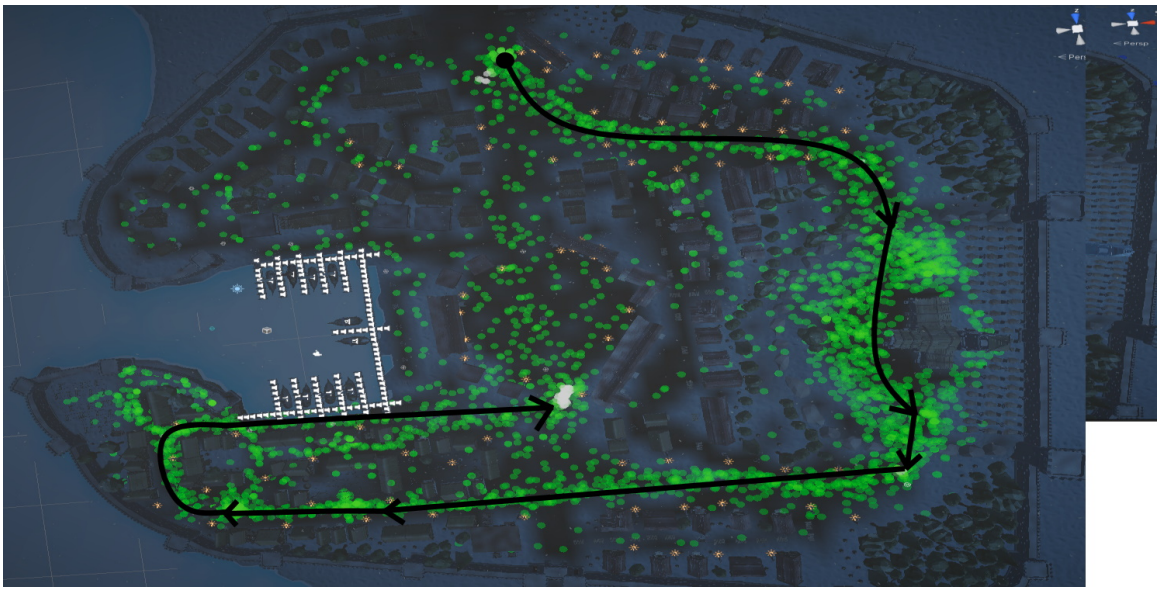


Figure 56: This figure shows the participants' position doing the second quest sequence. The black dot shows where the participants starts the game. The Yellow circles shows quest objectives the participant needs interact with of destroy. Green shows the positions the participants were in while the second quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area. This figure shows

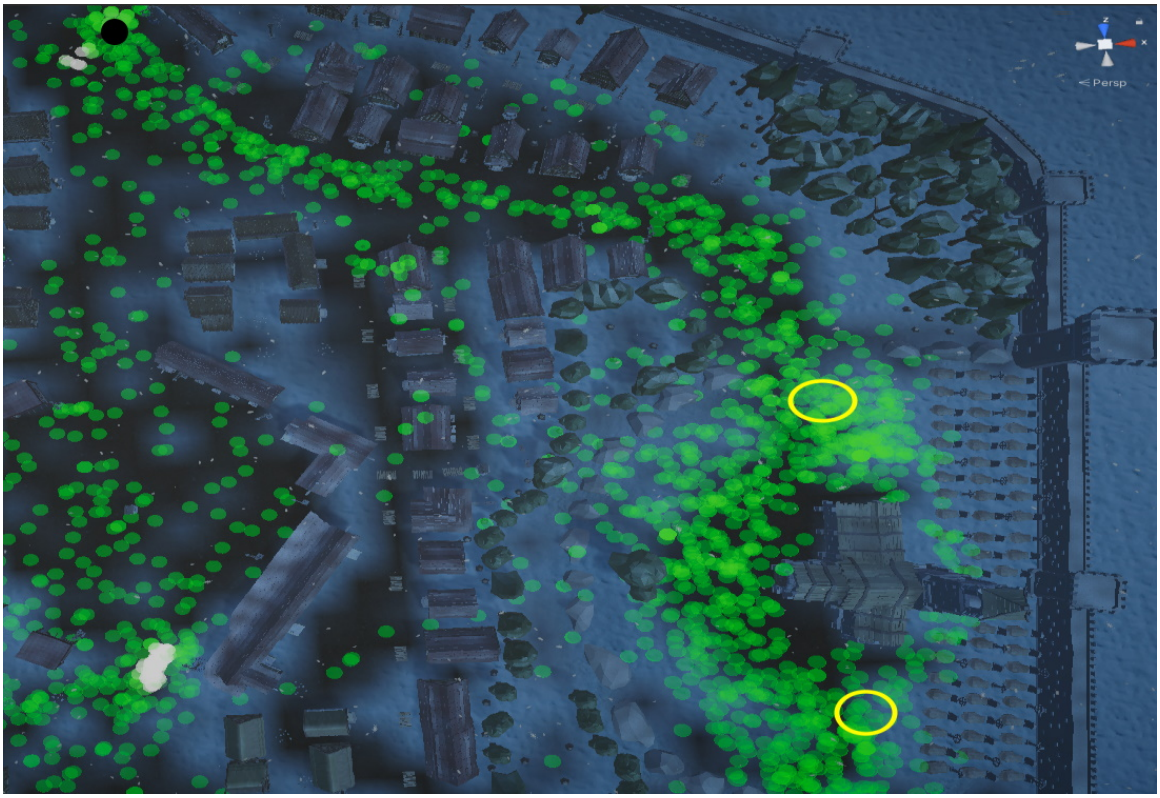


Figure 57: This figure shows the participants' position at the start of the second quest sequence where they need to turn on two bonfires. The black dot shows where the participants starts the game. The blue circles shows the positions the participant needs to search for. Green shows the positions the participants were in while the second quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions that are

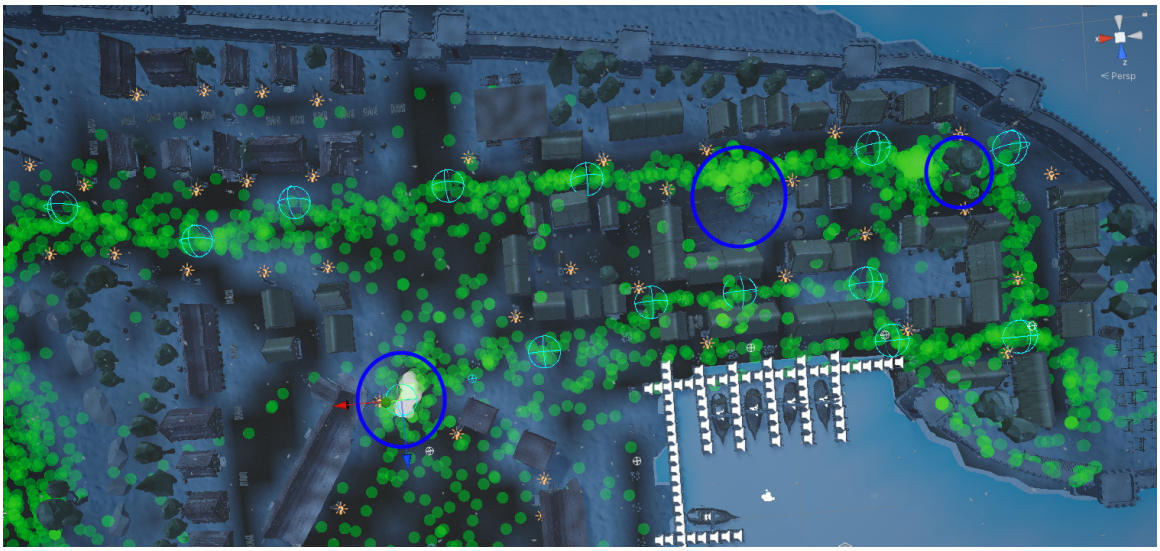


Figure 58: This figure shows the participants' position in the second quest sequence, where the participants are searching for a laundry place, a tree, and the lamppost in the marketplace is, these are indicated with the ring. The Cyan spheres show the path the fire spirit is moving through. Green shows the positions the participants were in while the second quest sequence was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions that are

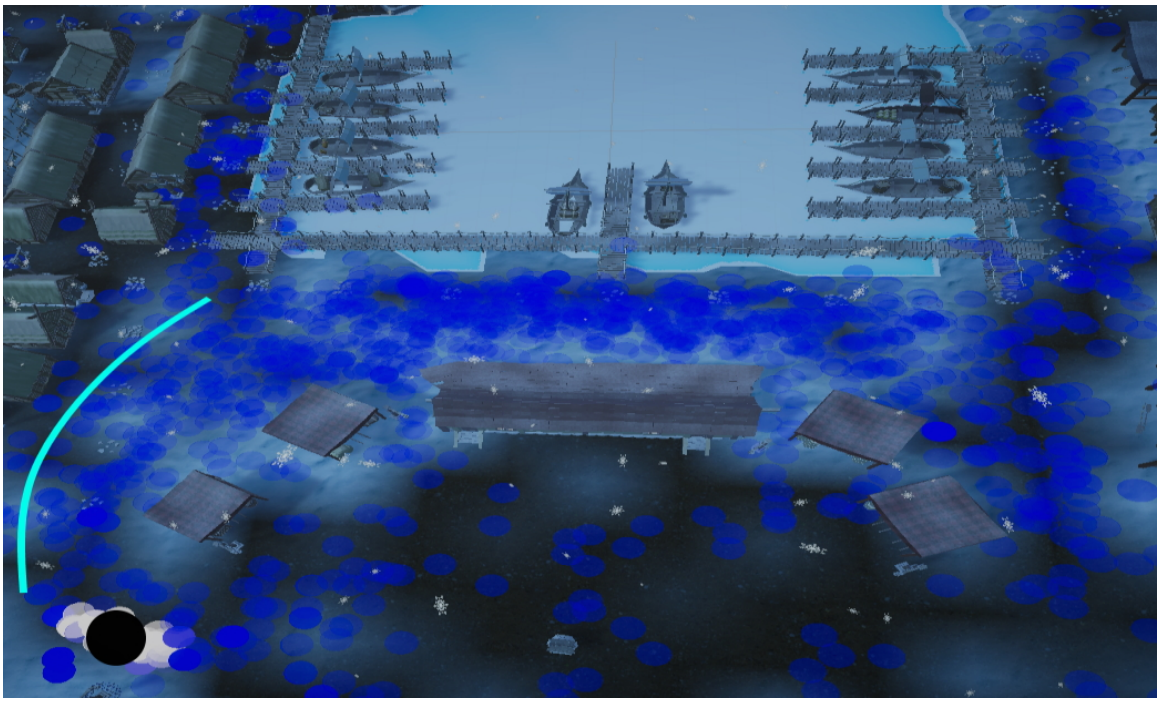


Figure 59: This figure shows the participants' position at the harbor doing the third quest where they have to defeat a ship in the harbor, it shows their movement doing the boss battle, the boss only moves within the harbor. The black dot shows where the participants starts the game. The Cyan colored line shows the path the camera moves doing the cut scene where the boss is introduced. Blue shows the positions the participants were in while the third quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area. This figure shows

6.3.3 Player motivation model - immersion

Since there was most participants who had selected that their player motivation was immersion in both conditions six and eight respectively. The research group chose to also review the movement

behavior in both conditions of those who had selected immersion.

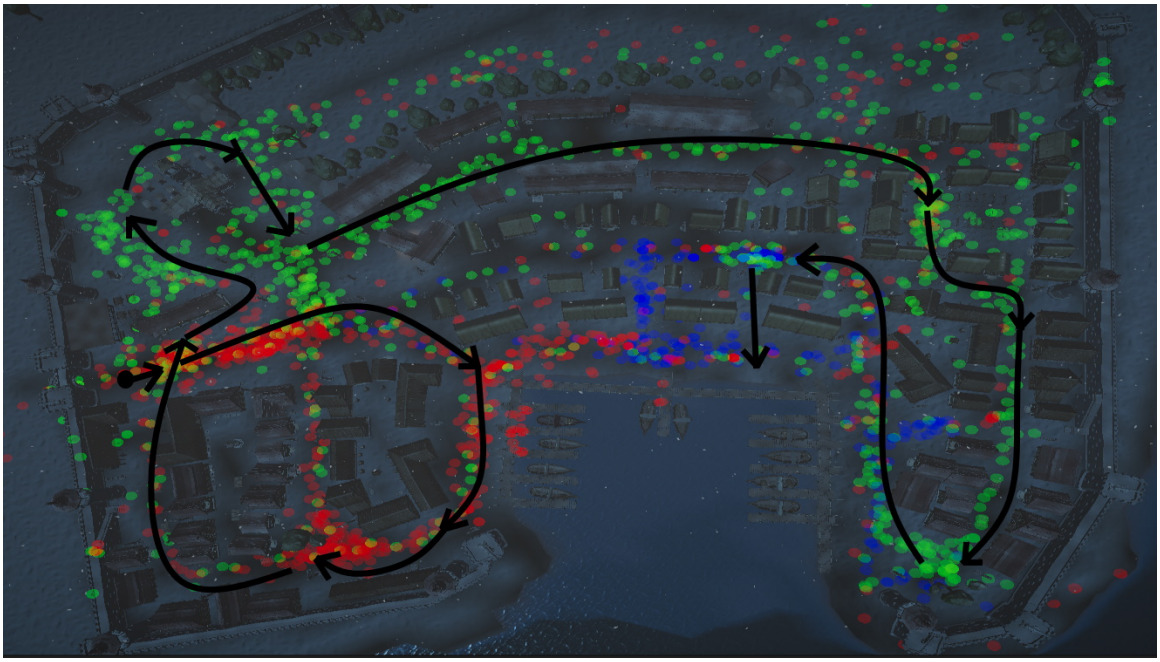
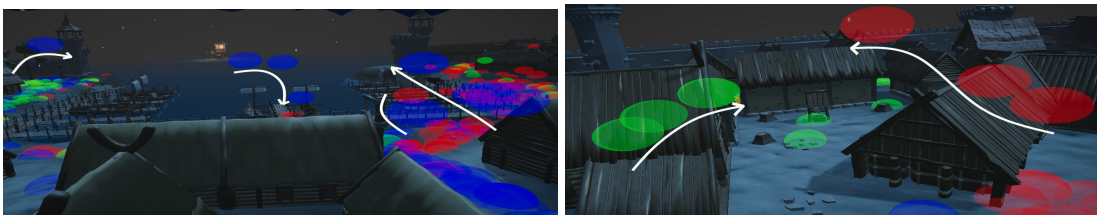


Figure 60: This figure shows the participants' position in the nuclei condition who have selected immersion as their main motivation when playing games. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. Red shows the positions the participants were on doing while the first quest sequence was active. Green shows the positions the participants were in while the second quest sequence was active. Blue shows the positions the participants were in while the third quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.



(a) (b)

Figure 61: The figures show the participants' position in the nuclei condition. The white line shows the direction of the participants' jump. The figure to the left (a) shows the immersion motivated participants choosing to jump from the roof of the buildings down towards the harbor, to fight the boss. The figure to the right (b) shows the participants jumping on the roof of the houses.

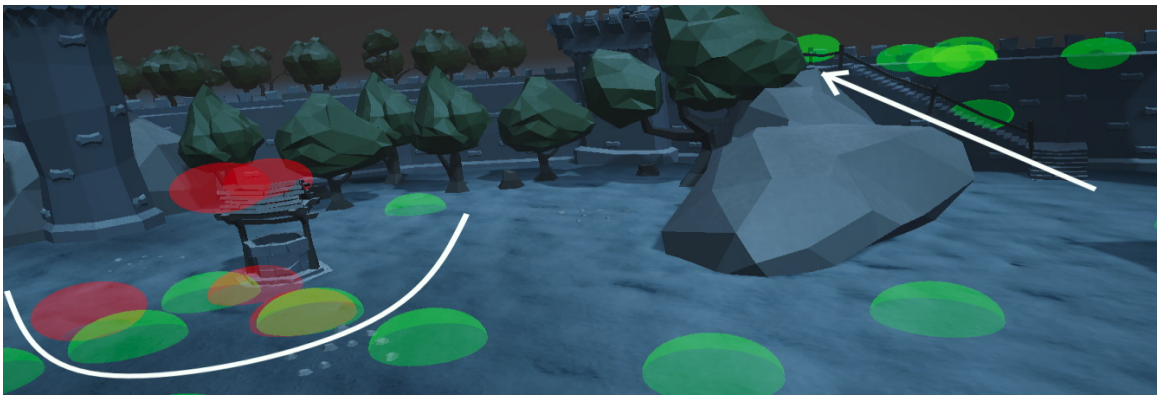


Figure 62: The figures show the participants' position in the nuclei condition. The white line shows places the participants explored. On the left side of the figure, it can be seen that the participants explored the garden and were interested in the well. On the right side, it can be seen that the participants were interested in climbing onto the wall. This figure shows

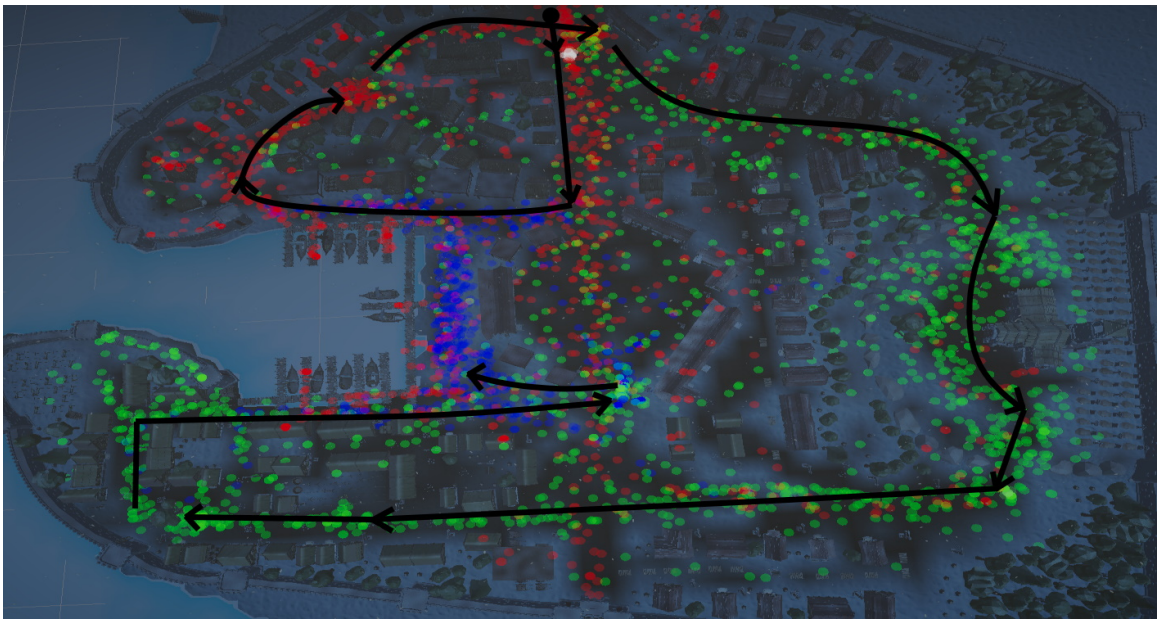
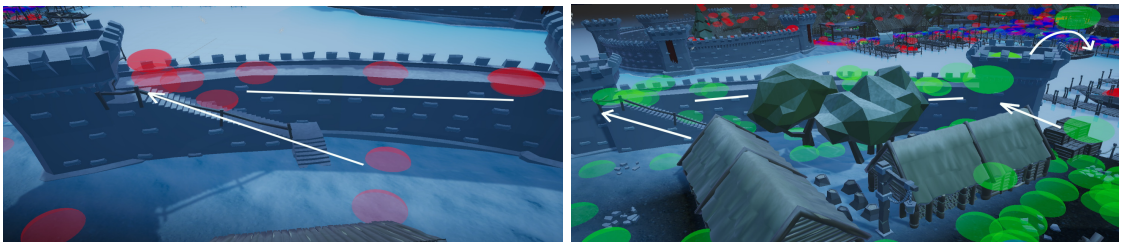


Figure 63: This figure shows the participants' position in the Sector condition who have selected immersion as their main motivation when playing games. The black dot shows where the participants starts the game. The black arrows shows the direction and the shortest route through the game. Red shows the positions the participants were on doing while the first quest sequence was active. Green shows the positions the participants were in while the second quest sequence was active. Blue shows the positions the participants were in while the third quest was active. The more concentrated the color is the more participants were in that area. The white color shows if there were more than 110 positions in that area.



(a) (b)

Figure 64: These figures show the participants' position in the sector condition who have selected immersion as their main motivation. The white lines shows the participants has explored of their own.On the figure to the left (a) it can be seen the participants climbing the wall close to where the first trapped fire spirit is located and some try to jump in the water, doing the first quest sequence. In the figure to the right (b) it can be seen the participants also climb the wall and also tries to jump in the water as in (a), (b) is located close to the last tree they need to find before they need to find the market place. The white line in top left of B shows the direction of the jump.

Figure 65: These figures show the participants' position in the sector condition who have selected immersion as their main motivation. The white line shows the direction of the participants' jump. On and off the buildings. The Yellow line shows the participants in the small public place. in this figure an example of where the participants has explored the small public space in the game.

7 Discussion

This section will analyze and discuss the data that was gathered from the Finding section. First, an analysis of the quantitative data will be done, followed by a qualitative data analysis. Then the section will observe the player position maps which will then be analyzed. This will then be followed by the limitations of the study. Lastly, the section will end with an evaluation of the level design of the two conditions.

7.1 Quantitative data analysis

From the Mann-Whitney U test in table 2, we can conclude that there is no significant difference between both groups for this hypothesis test and failed to reject the null hypothesis. A p-value of 0.394 and Cronbach alpha giving us 0.5352 also allows us to improve this hypothesis test and questionnaire for future studies.

First, the internal consistency and reliability of the questionnaire need to be iterated multiple times and calculated Cronbach alpha until it reaches above 0.8 to make it more consistent and reliable for future studies. Secondly, the questionnaire needs an overhaul of how many items and categories it needs to contain. The research group suggests at least two more categories than the original three, making it a total of 5 categories for the questionnaire. In addition, the number of items for each category can be increased to at least seven from the original 4 to 5 items per category. Lastly, a larger sample size than the one in this study will be required for most optimal hypothesis testing.

Different player motivation models were gathered from the questionnaire. This was to see if there was a behavioural pattern between people's motivation and their behaviour, but due to the sample size, not many of the same motivation types were repeated. However, based on figure 37, immersion player motivation was the most frequent in both groups, thus making it a clear candidate to explore their behavioral patterns in the game. For future studies, an investigation for all player types can be done if the criteria for a large enough sample size are met. We suggest at least 20 participants per player motivation.

From figure 41 and 42, the participants responded to how difficult it was to find the places in relation to the question. Both figures contain pictures used for each group with correspondent answers. We can see in figure 41 that is interesting is that there 3 more neutral answers, and 2 more very easy answers in experimental compared to control group, and that people in control found it consistently easier to find the laundry place in their layout. In figure 42 we can see that there 2 people in control group who found it very hard to find the specific lamppost compared to experimental, and 50% of participants from both groups found it relatively easy. they also appear similar in terms of how difficult it was to find specific lampposts depended on the condition the participants was in based on the pictures. The laundry place was easier to find than specific lampposts. To improve this for future studies, a more consistent size for both comparisons between a big place like a laundry and a small place like a lamppost will be most optimal when asked for this category of questions within the questionnaire.

The results from figure 39 regarding which layout participants thought they were in indicate that participants in the control group had better accuracy (55%) in guessing the correct layout compared to the experimental group (33%). This does not mean that people do not think over the layout they were in or layout geometric's when playing the game. Nuclei were the layout most participants selected between both groups, but it does not necessarily prove that most of the participants from the control group remembered better than the experimental group. This implies that participants remembered small groups or patchworks, which nuclei layout does look like. It is also interesting that more participants from the control group thought they were in sector layout than the experimental group. Concerning one of the questionnaire items, "Each area gave me a different feel" and "The layout of each area was predictable" might also shed some light on the results.

It was interesting to see that none of the participants selected the option that was the concentric layout, thus it would interesting to see in future studies, if participants could recogniser a concentric zoning layout, this could be added to compare all the other layouts used in this study, and to see if the players could detect different layouts when playing a game. Although, the consequence of doing so would be to recruit a third group into the hypothesis test, which would require more participants

and an analysis of variance (ANOVA) test to see the variance between each group and layout.

The results of the time participants spent on table 3 show that the total time was almost similar, but the amount of time spent between Quest 2 has more than 40 seconds difference between each group, where the sector group was fastest, this is interesting because the Sector level is geometrically bigger than the nuclei level which meant that the researches expected that the nuclei group would be the fastest, this might suggest that the participants felt that one of the positions they needed to find were more difficult to find than in the sector model based on figures 41 and 42 it suggests that the participants generally felt that the lamp post was more difficult to find for the nuclei condition than in the sector condition based on time even though there only was two more in the nuclei who gave it a score over 3 than in the sector model. The time in Quest 3, the nuclei condition was fastest in the third quest with an average of 50 seconds. This was interesting since the researchers expected it to be more balanced and more similar to the time in Quest 1 on table 3. A reason could be that the harbour's height at the nuclei level is higher than in the sector condition, making it easier for the participants from nuclei to complete the boss. Unfortunately, one participant had to be removed from the control group due to a 28 min game session, creating a massive outlier for the time average. The difference in time in Quest 2 and Quest 3 may indicate that size of the layout did not significantly influence the time players spent while pathing inside the game.

7.2 Qualitative data analysis

The qualitative comments from section 6.1.2 give us an insight into how many areas of the town they would have drawn and what to call them. The respondents were 112 places with an average of 5.6 in the control group and 90 places with an average of 4.2 in the experimental group. Each place was categorised and compared between each other, and then they were grouped into the five Lynchian elements as mentioned in section 2.1. The two categories with the most frequent elements were Landmarks and Districts. This is interesting since the urban ecological models used for the layout of both conditions were mainly based on zoning/districts, so it makes sense that many participants mentioned something about districts.
The research group suspects that a reason why participants from the nuclei condition, although a geometrically smaller level, remembered more things than the participants from the sector level. This might be because the nuclei condition included more districts and edges in the layout, which are two components from the Lynchian elements that help people construct a mental map over the environment.

Subjective landmarks are like landmarks but are more personal to the player as it had more significance as it focuses more on internal connection rather than external connection. This is interesting because, as mentioned in section 2.6.3 landmarks are the most used element for wayfinding, and the landmark elements in the prototype were the most mentioned elements from the questionnaire in both conditions, and this might be because it is an attention-seeking element and memorable.
Not many participants answered within the paths, edges, and nodes categories. However, the research group did not expect it since some of these elements require the participants to down rather than up, thus resulting in the participants' losing their field of view.

The interview from section 6.2 had participants from both groups (6 total) who gave the research group interesting feedback regarding various aspects of the game. For the question "Could you feel that each area/district had its own feel to it?" one participant mentioned from both groups (ID02 and ID04) that most of the buildings were very uniform and did not see any difference between each district. This is interesting since the research group had problems making enough variations of the limited models included in the project, as mentioned in section 4.2.1. If enough models were gathered and created more variety, it could potentially change and make the districts more differentiating for participants.
When participants were asked the question, "Was there at any point during the game you felt lost?" it was the participants from the control group (ID04 and ID06) who said that since they could not differentiate much of the buildings which could have confused them and led them to be lost. One participant (ID01) from the control group mentioned that the colours were very flat, which could be a factor how it made it hard for the participants to differentiate the buildings in each district.
When participants were asked the question "What do you remember about the game's story?" it was interesting and had varying answers depending on the players themselves from either group. ID01 from the control group wanted to see more about what happened afterwards when they finished the

game, indicating that they invested in the concepts of the world itself. ID04 from the control group said that the story was more of a vehicle for the game's theme, so there was not much of a story, according to this participant. Another interesting response came from ID03 from the experimental group who wanted to go around the game and do as much as possible with the newly acquired hammer, so they did not pay much attention to the story either and instead was interested in the game's theme.
When participants were asked the question, "Could you describe your mood throughout the game?" ID02 gave an interesting answer to this question. They felt that the world was cold and dark from the environment, which meant that the theme was again dominant over the story, and added that they felt the world was a ghost town and wanted more NPCs to talk to, which indicates that this participant felt that it could use more live to the environment itself and not feel as barren.

7.3 Player position map

7.3.1 Multiple Nuclei observations

Figure 46 shows the overall positions of the participants in the nuclei condition, it can be seen that while the participants were doing the first quest they were spread around the map, and the research group generally assume that the red spread is due to the participants are exploring the map. However, some of the spread might also be due to some of the participants who could not find the first trapped fire spirit as participant ID04 said doing the interview that he could not find the trapped fire spirit and needed to moved through the whole town until he found it.

In figure 47 the participants' movement while they were doing the first quest in the nuclei layout can be seen. Some of the participants explored much of the town before they continued.
However as can be seen on the lower left of figure 47 or on figure 48 there is a high density of participants who move through the left part of the harbor down to the ice crystal, thus makes the researchers expect that the majority expect that the participants did not have too much difficulty to find the ice crystal that has trapped the fire spirit.
What is interesting to see in figure 48 is that there is a higher density of participants who walked a different path towards the inn in order to progress, than there was of participants who followed the route the fire spirit would move towards the inn.
This suggests that the participants have had gain a good mental map over the first area in the control condition, in the interviews there was no mentioned difficulty to find the inn.
Figure 49 shows participants' position in the nuclei map doing the second quest. It was expected that the participants would be searching more doing the second quest than in the first quest, one because it was a larger area and two because they have not been introduced to that area of the town.
However, it is interesting to see the strong density of green going through the same path as the fire spirit would take. Which might indicate that the participants followed the fire spirit.
In figure 52 it can be seen the different positions and movements the participants did doing the boss fight, there are generally three main positions the participants took to see the green rings in figure 52, but they did not move as much as they did in the sector condition see section 7.3.2.
It is also interesting to see the three main paths the participants took down towards the docks see the cyan lines in figure 52 because the research group would have expected that there would be more participants who used the path to the left because, when the boss cutscene starts and the camera moves through that paths. So it was expected that the participants would follow the cameras path. But not many participants chose to take that path, this is different than in the sector condition see section 7.3.2. It might be because they are standing quite close to middle passage they used see the middle cyan line.
But as it can be seen on the the two lines (the middle and the right) the participant used the space between the houses to create Steiner points which as Totten describes as people who create their own shortcuts in the environment, which also suggest that the participants did have a good mental map over how they could get down to the harbor.

7.3.2 Sector model observations

Figure 53 shows all the participants' positions in the sector map, in general, the participants' positions are on the paths that the researchers expected, and there is some spread on the map that does which the research group expects are participants who are exploring.
Figure 54 shows the participants' movement doing the first quest sequence, the highest density of red

can be where the researchers expected, it is, however, interesting to see many participants walked onto the docks, which not many participants did that in the Nuclei condition see section 7.3.1. However there is also a big spread of red throughout the map, here the researchers expect many participants explored the level since the researchers expect that many people tend to explore a level at the beginning of it, though some of the spread might also be due to some of the participants was lost.
Figure 55 shows the area where there is the most density of the first quest sequence, and where the different quest locations are in the town. Which is shown by the rings, it is interesting to see the participants have walked all around the harbor and on the docks. What is also interesting to see is that most participants followed the route of the fire spirit, instead of finding another way to the inn, this was in contrast to the participants' chosen path in the nuclei condition in figure 48 and was mentioned in section 7.3.1. Though it should be mentioned that the path the fire spirit takes is also the most direct path to the in, so based on figure 55 the research cannot see if the participants followed the fire spirit or just took the same path.
Figure 56 shows the participants' movement in the second quest sequence, though there is some spread in the starting area where the first quest sequence took place, not much, most of the dense areas are where the research group expected the density to be. some of the spread does also suggest exploration for instance the spread in the side passages close to the main routes.

Figure 57 shows the participants' movement in the first part of the second quest sequence, here the participants need to go from the inn where the black dot is to the church, what is interesting on the figure is that the direct path to the church is not as dense as the research group expected, and it can be seen that several participants have chosen to take different paths other than the direct path to the church. It can also be seen that the participants have explored that part of the area that leads up to the church.
In figure 58 it can be seen that the path from the laundry place to the tree is most dense, this might be due to their close location to one another, but what is interesting is that the density on the path which the fire spirit takes is less dense up to the laundry and from the tree to the market place than when the participants should find the same positions in the nuclei condition which was mentioned in section 7.3.1 which can be seen on figure 51.
It is not clear however based on figure 58 how much of the spread is due to people having trouble finding the places they need to find or exploration, however, based on figure 41 it does suggest that few participants felt it to be difficult to find the laundry place since only three participants scored the laundry place a difficulty score under 3. This suggests that the spread is more due to the participants' exploration of the area than they were lost, for instance, it can be seen that some of the participants take some of the side passages and visits the small public squares that were designed in the two different districts.
In figure 59 the participants' movement doing the last quest where they need to defeat the boss in the harbor, while they are fighting the boss, what is interesting to see here is that on the bottom left of the figure 59 indicated with the cyan colored line, is the path where the camera moves doing the cut scene showing the boss and where the participants needs to go. More participants chose to go that way, than there were in the nuclei condition as was mentioned in section 7.3.1, but then in the bottom right corner on figure 59 is there also several participants choosing to go the other direction, this might be because many of the participants chose to go that direction at the beginning of the game when they were asked to sink two ships. Lastly, it is interesting to see that the participants' positions is more spread out around the harbor in the sector condition than in the nuclei condition see figure 52, the researchers' explanation can be seen in section 7.3.4

7.3.3 Player position map for immersive motivated participants

the participants' position who is motivated by immersion in games in the nuclei condition can be seen, the research group did expect them to explore some of the environment, to help them to gain a feel of the environment, and the environmental storytelling the environment could give them.
As can be seen on figure 60 and 63 many of them explored the town area, and did not nessersarily stuck to the shortes paths which the arrows shows on figure 60, 63, 62, and 64.
Figure 62 shows that the participants explored the garden in the nuclei condition and enjoyed and explored the top of the wall surrounding the town. In figure 64 the participants also enjoyed climbing onto the wall that is used for the entry of the ships that enter the harbor and there was even one participant who tried to jump into the harbor.

The participants also did enjoy jumping one of the buildings on the left image in figure 61 it can be seen that the participants have jumped on to a building in order to jump down to the harbor, which is an creative way to get down to the harbor.
On the image to the right on figure 61 it can be seen that the participants also jumped on the buildings, and even a participant from the first quest explored the other end of the town where the second quest is active.
The participants in sector model also seemed to jump on the buildings an example of this can be seen on figure 65 here it can be seen that a participant in the second quest (green) is jumping from the ground on to the building and is on a direction to another building.
Furthermore it can be seen that a participant in the first quest (red) is jumping from a building in the marketplace to another building over toward the trees. There were also some participants from the second (green) and the third quest (blue) who explored the small public area indicated by the yellow line.

7.3.4 Player position map analysis

Based on the player position maps in figure 46 and 53 there is in general no big difference between where the clusters and the spread is in both conditions. The sector layout has some more spread than the nuclei layout but that is to be expected since the sector layout is a geometrically bigger than the nuclei layout.
But based on figure 40 it can be seen that more participants felt it was very easy to navigate through the level but there was also one participant who felt it was very difficult to navigate through the level and this is different from the nuclei layout where 50% of the participants gave the layout a score on easy or very easy, base on that figure the difficulty of navigating between the two conditions would be more or less the same.
But based on the interviews two participants ID01 and ID04 who both were in the nuclei condition felt that it in generally difficult to navigate at the level, yet none of the interviewed in the sector condition said that it was difficult to navigate in the sector condition.
This is interesting because there is in general more spread at the sector level see figure 53 than at the nuclei level see figure 46.
Thus generally there is not that big of a difference however as mentioned in section 7.1 and can be seen in table 3 there is a time difference the research group did not expect between the two conditions in quest two. By looking at figure 49 and 56 it can be seen that the participants in the nuclei condition might have been more lost than the participants in the sector condition.
Figure 49 shows that the participants walked all over the map and in the area, they were in doing the first quest sequence there is a higher density than there is in figure 56 where the participants in the sector condition were in.
Even though the sector condition also has some spread in that area it is not to the same degree as the participants from the nuclei condition, it might be because there was not clearly signified for the participants in the nuclei where they need to find a lamppost in the street between the harbor and the market place, and not due to the difficulty finding the laundry area because as mention earlier in section 7.1 in fig 41 there was not that big of a difference between those conditions.
But there was a difference between the participant finding the last position in the conditions as was mentioned in section 7.1 and can be seen in figure 42. This difference might be the cause of the bigger spread in the nuclei condition.
Furthermore based on the figures 47, 54,49, 49, and where the participants are expected to be around the map for both the first and second quest sequence, it suggests that the participants generally explored more of the levels general area, than they do in the second quest sequence, other than neighboring areas related to the quest. The research group does acknowledge that some participants felt lost when playing the game but based on figure 40. This shows that around 70% of the participants in both groups self-evaluated themselves selves, had it easy or neutral wayfinding experience in the game, thus the research group expects that most of the spread is from exploration rather than from participants who were lost in general.

Another interesting find from the player positions maps was that the participants in the sector condition, generally jumped more often on the buildings than in the nuclei, even though there also were some who did it in the nuclei condition.
A reason for this might be due to the terrain height being higher and in different stages in the nuclei condition where the terrain height in the sector condition was mainly the same except for the church area.

The difference between density and spread between the two conditions doing quest 3 is is interesting to see. There is more spread around the whole harbor in the sector model, than there was in the nuclei condition see fig 52 and 59. A reason might be that the terrain in the nuclei has a higher ground than in the sector, making the participants feel less threatening thus resulting in an unintentional reverse prospect space and refuge space [58], resulting in the player feels safer and do not want to move much in the nuclei condition wherein the sector condition the participant felt the area to be more a prospect space[58], thus did not feel safe while they were fighting the boss thus resulting in the participants moved much more in the sector condition.

7.4 Limitations

The questionnaire was inspired by Höhl, Kharvari, and Klinker's study but it could be modified to be more reliable as was mentioned in section 7.1, the current questionnaire consists of three categories describability, simplicity, and memorability.
An Additional category the research group recommends for future study is a category that explores sequential and geometric metal map / spatial memory, this category according to Passini can show the participants' degree of their mental model of the layout. People with a low mental model of an area will remember the routes and the area in a sequential way for instance: first I was here then there [46].
While people with a better mental map of the area or building will the ability to remember the area as a geometric form, thus they will understand that there might be multiple paths towards the same destination [46].
The data from this category could be collected by, asking the participants how many different paths they can think of to a certain destination potentially with an image of the destination and from a start position for instance where the participants start at the beginning of the game or from the church, etc, with a follow-up question, ask describe the following paths.

The research group believes it was a mistake only to include two questions that asked the participants how hard it was to find specific objects within the game. Because this made observing and analyzing the player position map a bit more difficult since the research group did not have data on which elements were more difficult to find than others. Other than the laundry and where the participants would end the second quest. However, it should be noted that the questionnaire's question was included because the research group expected these two positions would be the positions that were the most difficult to find in the game.

After the test had started, the research group found out that they had overlooked a design flaw in the test. The research group believes that a better way to see how the participants navigate the level could be done through a slight change in the test, e.g. instead of the participants freeing the fire spirit, they then need to find the other spirits that are trapped throughout the level.
A better way might make the participant follow the spirit throughout the map, so they have been everywhere they need to be before they need to start searching for the other spirits that are trapped throughout the level. After they then have found the spirits boss will then be activated since based on feedback from those who were recruited in real life and from the interviews, it seems like most participants enjoyed the boss encounter. Thus, it seems like a good reward for the player to end the game with. In addition, the research group believes that this will reduces the number of participants who felt lost in the game or felt it was difficult to navigate through it.
The research group believes that this will reduces the number of participants who felt lost in the game, or felt it was difficult to navigate through it.

The JSON save file worked well to get the positions from the participants; however, based on the analysis and observations of the player position map, see section 7.3. The JSON file could include more information that helps create better analysis and observations. One thing is to save the distance between the fire spirit and the participant. This could help the research find out if the participants just followed the fire spirit or just took the same path as it.
Another addition to the JSON file could include Unity's transform.forward vector. This way, the research group can see which way the participants are moving, which could be visualized when reading the player position map. This will also make it easier to see how the participants is moving going directly towards the destination, exploring or is wandering lost around in the level.

7.5 Post test evaluation of the level layout

The two levels that were designed for this project the nuclei and the sector condition used all the Lynchian elements to help create the participants' mental map of the two conditions. The nuclei condition had more edges and districts than the sector design. The amount of edge and districts in the nuclei condition was to be expected due to the type of model the nuclei is.
Both conditions have around the same amount of the Lynchian elements implemented, however, the nuclei condition does have a garden as an additional landmark which the sector does not have. Ssince the garden is not used for any quest the research group does not expect it to have a notable wayfinding effect between both conditions.
The most notable difference between the two conditions and the Lynchian elements, are landmarks, while both conditions have almost the same amount of landmarks, the last position the participants needed to find in the nuclei conditions, was missing an equal distinctive landmark as the marketplace was in the sector model. The only reason why the participants in the nuclei condition were not supposed to end the last search quest in the marketplace was that the research group wanted the participants to have around the same distance to the harbor.
This might have been a mistake since based on the time in figure 3 it took the participants more time than expected to find the lamppost on the street between the harbor and marketplace.

Based on the quantitative data and the player position maps the size difference between the condition does not seem to have had any affect on the participants' abilities to navigate through the environments. There were even participants in the interviews who said that they would have wanted or expected the town to be bigger. The main effect of the size difference is the time difference between both conditions, except for the time difference in quest two, as was mentioned earlier.

Both of the conditions used light as a navigational aid for the participants, however, there was a design oversight with the default lighting in the nuclei condition. The default light was so bright that when new light was turned on during gameplay, it did not attract the players as much as the light did in the sector condition.

The research group sees the use of narrative wayfinding aid as a success, doing the two cutscenes camera moved towards the area where the participants needed to go, and non of the interviews mentioned any problems in regards to finding those areas. Another narrative navigational aid that was used was during the search quest the hammer told the player what they needed to find. The research group sees this with mixed results, this navigational aid did work and did help the participants find the different objects they needed to find, but the descriptiveness of the dialogue was optimal, and it could have been better.
The research group believes that the data gathered could have been more useful if the town in both conditions was more complex. This could have been done by increasing the towns' sizes and adding more clusters of houses. In addition, the garden in the nuclei condition could have been made smaller similar to the small green areas that were in the sector condition, so there was more space for more districts. In the sector condition, the main roads could have been made thinner thus making more dense clusters of houses. This could have created more clear paths due to the walls of the buildings but also created more small passages through the clusters, allowing the participants more different paths to the different areas they have to find.
The main problem with doing this with the current prototypes is that the research group has a limited amount of different buildings which could end up having a negative effect on the participants' wayfinding abilities. One of the interviewed participants said that everything looked the same which had a negative effect of his understanding of the layout and districts of the town. Other than acquiring new models to add to the different conditions, using different types of contrasting overlay of colors on the texture could also help the participants better differentiate the different districts. As well as a different ambient or background sound playing when the participant enters another district.
The research group suspects that a reason why some of the participants felt it was difficult to find the different objects they needed to find in the second search sequence was that the participants were not properly introduced to the low residential area. This could have been solved by having some non-search quest in that area similar to how the participants go from one end of the first area down. Where they start by finding the hammer, then go down to the harbor, where they need to

find the trapped fire spirit which is in the corner in the opposite to where they started, and where at the end of the quest they end up close to where they started the game.

The pre-production phase of the design also helped to design the final implementation of the level, as it was a huge help to the research group to know what and where notable areas should be in relation to each other as well as the layouts.
Using the sector theory and the multiple nuclei as a foundation for the layout of the level did create two levels that were distinct from each other, both as a topology map and playing through the levels. Neither of the conditions seems to have a negative effect on the participants' wayfinding ability. The layouts also seem to be able to create different types of memorability between them, playing through them and the difference in the number of districts within them, thus using the sector and the nuclei condition did end up as two distinct levels even though they include much of the same Landmarks: church, harbor, market place. As well as districts.

8 Conclusion

This study has explored different types of wayfinding techniques and elements that can be used to help people to navigate in both the real world and in virtual environments. The study has explored urban design and different urban growth models that were common to see in cities during the 20th century. The research groups found parallels to how the zoning of the ecological models was with how Divinity original sin 2 and World of Warcraft have zoned their layouts in their games. However the zoning layout used in the mentioned games was mainly used for difficulty zoning and not general design layouts as it is used in the ecological models. This made the research group wonder if different types of zoning layouts in games have an affect on people's wayfinding ability in games which led the research group to the final problem statement:

> "To what extent does a linear game based on sector spatial layout have an affect on a player's perceived wayfinding when compared to a linear game based on multiple nuclei spatial layout?"

To answer the final problem statement the research group first needed to find out if there was any difference in the participants' perceived wayfinding ability between the models' nuclei and sector. This then led to the following hypnosis:

> H0 = There is no significant difference between sector layout and nuclei layout can affect a player's perceived wayfinding in a game.
>
> H1 = There is a significant difference between sector layout and nuclei layout can affect a player's perceived wayfinding in a game.

The research group gathered a total of 41 participants (20 in control and 21 in experimental) and conducted a hypothesis test based on this sample size. The Mann-Whitney U test gave the research group a p value of 0.394, therefore we fail to reject the null hypothesis. Thus, answering our final problem statement that there is no significant difference of player's perceived wayfinding between sector and nuclei layout. The cronbach alpha value is 0.5352 which means that the questionnaire has poor consistency and low reliability, and needs further testing for improvement. However, the interviews and player position maps revealed interesting results. The interview revealed that players felt more lost in nuclei layout than sector layout. The player position maps revealed that players explored the game more during the start of the game rather than later.

There is not a huge difference between where the clusters and the spread is in both conditions. The sector layout has more spread than the nuclei layout but it is to be expected since the sector layout is a geometrically larger than the nuclei layout. The player position maps also showed that the participants explored more of the general level during the first quest than in the second and third quest.

Despite nuclei layout being smaller than sector layout, the responses from nuclei participants does get more mentions of places like landmarks and districts more frequently of 112 in total and average 5.6 than sector layout where the responses mentioned a total of 90 places with an average of 4.2. The research group suspects this might be due to extra amount of edges and districts in the nuclei layout, which are elements from the Lynchian elements which help people navigate throughout an environment. If this is the case then it would interesting to see in future studies if the nuclei layout is better to construct a mental map than the sector theory is.

So in conclusion using the sector theory and the multiple nuclei as a foundation for the layout of the level did create two levels that were distinct from each other, both as a topology map and playing through the levels. Based on the data gathered, the two conditions seem to have neither a positive nor negative effect on the participants' wayfinding ability. However, some of the data does indicate that there might be some difference between the construction of the participant's mental map and the condition they were playing. Therefore the research group recommends more research is needed to conclude if there is a difference in wayfinding, the participants' mental map, and the zoning layout of the level.

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9 Appendix

Links to various components used for AV-production

Voice over:
https://www.voicebooking.com/en/free-voice-over-generator

Different images and gifs:
http://www.dadiu.dk/gamedesigner
http://www.dadiu.dk/level-designer
https://giphy.com/gifs/warcraft-world-of-warcraft-psmk2jPQD9SehTG3b
https://giphy.com/gifs/warcraft-world-of-warcraft-jwKoQccpkWp7ivRCee
https://downloadcentral.dk/world-of-warcraft/6145
https://gifer.com/en/Um8A
https://giphy.com/gifs/retrofunk-afv-xTiTnooneW4SYfch8Y
https://www.udemy.com/course/level-design-master-class/
https://fabrikbrands.com/the-wonders-of-wayfinding-design/
https://www.worldofleveldesign.com/categories/game_environments_design/mirrors-edge-color.
php
https://busratanoglu.wordpress.com/2019/10/03/the-city-image-and-its-elements-kevin-lynch/
https://www.scribbr.com/methodology/between-subjects-design/

https://giphy.com/gifs/chemistry-science-experiment-no-idea-what-im-doing-fUZHXuE94BN2wtSbUS
Music:
https://pixabay.com/music/main-title-where-the-brave-may-live-forever-viking-background-music-
https://www.youtube.com/watch?v=bISSCB9XWvg
License for the Sound effects and the boss music
https://pixabay.com/service/license/
Model stables
https://www.cgtrader.com/free-3d-models/various/various-models/medieval-stall-c5cb2b14-6538-402

P10 - Master's Medialogy Project

Thank you for participating in our semester project test (Windows only). You will be playing a short game using traditional WASD controls along with Sprint (shift) and Weapon interaction (left mouse click). We prefer that you use a mouse for this game and turn on the audio.

Firstly, you will go through the consent form and demographic info, and then you will download the zip file containing the game. You don't need to install anything, so you need to click on the .exe file to run the game. We prefer that you have both the questionnaire open alongside playing the game. Once you finish the game, you can go back and answer the questionnaire. Enjoy!

*Skal udfyldes

1. Consent Form - This test will involve a gaming prototype made by a Master Thesis Medialogy group at Aalborg University in Copenhagen. The test will collect the data from the questionnaire, and record your position and path inside of the game, in order to see behavioral patterns. Please allow the game to be played through your firewall. The data being gathered will be kept for 3 years, sorted out, and will not be published to the public in any sort of way. Your answers will be anonymous throughout the study and only be referred by an ID number. You are allowed at any point to withdraw from the test. This test is for study purposes only. If you have any other questions you can contact one of the study coordinators through this mail: tlaur17@student.aau.dk *

   Markér alle, du er enig i.

   ☐ I agree to participate in the experiment

2. Alias - please write an alias, you can use if you want to retract your data *

3. Gender *

Markér kun ét felt.

- ◯ Man
- ◯ Woman
- ◯ Nonbinary
- ◯ Prefer not to answer
- ◯ Andet: _____

4. Age *

_____

5. Please choose what type of player you find yourself being like when playing a game *

Action "Boom!"	Social "Let's Play Together"	Mastery "Let Me Think"	Achievement "I Want More"	Immersion "Once Upon a Time"	Creativity "What If?"
Destruction Guns. Explosives. Chaos. Mayhem.	Competition Duels. Matches. High on Ranking.	Challenge Practice. High Difficulty. Challenges.	Completion Get All Collectibles. Complete All Missions.	Fantasy Being someone else, somewhere else.	Design Expression. Customization.
Excitement Fast-Paced. Action. Surprises. Thrills.	Community Being on Team. Chatting. Interacting.	Strategy Thinking Ahead. Making Decisions.	Power Powerful Character. Powerful Equipment.	Story Elaborate plots. Interesting characters.	Discovery Explore. Tinker. Experiment.

Markér kun ét felt.

- ◯ Action
- ◯ Social
- ◯ Mastery
- ◯ Achievement
- ◯ Immersion
- ◯ Creativity

6. Select the average number of hours you play video games per week *

Markér kun ét felt.

- None
- Less than 1 hour
- 1 - 3 hours
- 4 - 9 hours
- 10+ hours

7. How good would you say your sense of direction is where 5 is very bad and 1 is very good *

Markér kun ét felt.

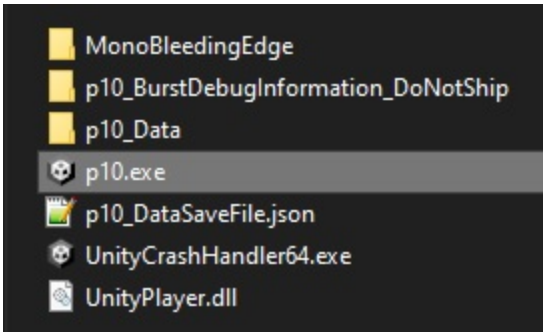
	1	2	3	4	5	
Very good						Very bad

Download the game

Please follow the link to download the prototype game:

Windows: https://drive.google.com/file/d/1GbdquMil6zP8aliecv367WNf-cLgrHzy/view?usp=sharing

Once you have downloaded the game, please extract/unzip the file you have downloaded and play the file. Please wait until you are finished with the game before filling out the next parts of the questionnaire.



8. Have you downloaded the game? *

Markér kun ét felt.

- [ ] Yes

Post game questionnaire

9. How complex do you feel the layout of this town was? Where 5 is very complex and 1 is not complex at all *

Markér kun ét felt.

	1	2	3	4	5	
Not complex at all	◯	◯	◯	◯	◯	Very complex

10. How confident are you in that you would be able to draw a sketch of the town? Where 1 is not confident at all and 5 is very confident (You do not have to draw the actual sketch) *

Markér kun ét felt.

	1	2	3	4	5	
Not confident at all	◯	◯	◯	◯	◯	Very confident

11. Would doing such a sketch of this town be difficult or easy? (Don't worry about your own degree of 'artistic' ability) *

Markér kun ét felt.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

12. How accurate would you be of the town sketch you'd have drawn? *

Markér kun ét felt.

	1	2	3	4	5	
Very poorly						Very accurately

13. My sketch would represent the arrangement of the town... *

Markér kun ét felt.

	1	2	3	4	5	
Very poorly						Very accurately

14. How many different areas of the town would you have drawn, and what would you have called them? *

15. How difficult did you feel it was to navigate in the town? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult						Very easy

16. How difficult was it to find the laundry place in this town, as shown on the image? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult	◯	◯	◯	◯	◯	Very easy

17. How difficult was it to find the spirit near the lamppost on the street behind the market place, as shown on the image? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult	◯	◯	◯	◯	◯	Very easy

18. How much do you agree with the following statement: Each area gave me a different feel? Where 1 is disagree and 5 is agree *

Markér kun ét felt.

	1	2	3	4	5	
Disagree						Agree

19. How often did you feel lost while playing the game? Where 1 is all the time and 5 is never *

Markér kun ét felt.

	1	2	3	4	5	
All the time						Never

20. How accurate do you remember the five places where there was the circle of flowers was placed in the entire town? Where 5 is very accurately and 1 is not at all *

Markér kun ét felt.

	1	2	3	4	5	
Not at all						Very accurately

21. How difficult do you think it would be to direct another player through this game? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult						Very easy

22. Did you find this town a relatively easy or a relatively difficult place to “figure out”? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult	◯	◯	◯	◯	◯	Very easy

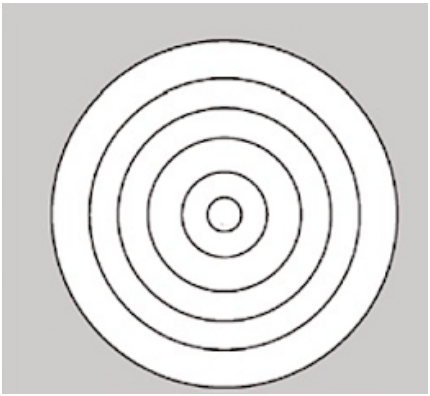
23. The layout of each area was predictable. Where 5 is very predictable and 1 is very unpredictable *

Markér kun ét felt.

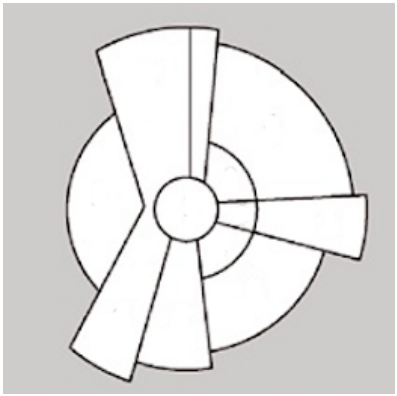
	1	2	3	4	5	
Very unpredictable	◯	◯	◯	◯	◯	Very predictable

24. Which one of the images below best represents the layout of the town? *

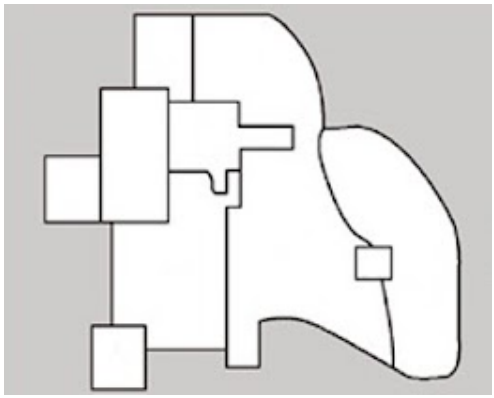
Markér kun ét felt.



Layout A



Layout B

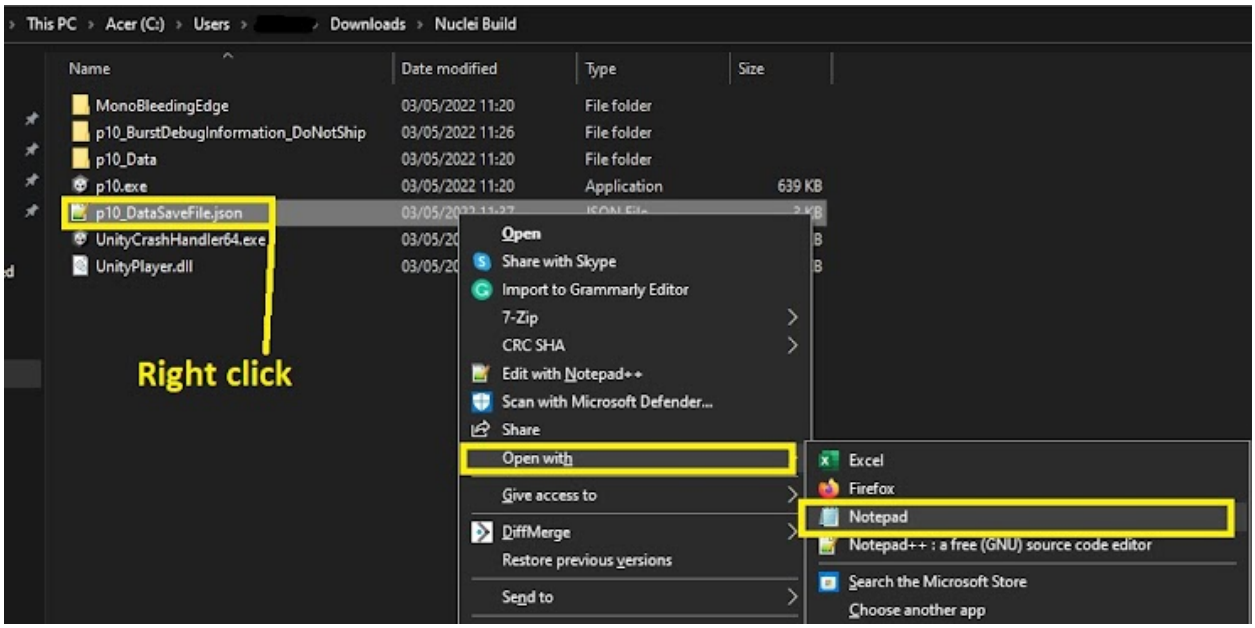


Layout C

Upload In-game data

Please go to your game folder and go to your p10__Data folder and find the .json file, open the file and copy-paste the entire text of the file into the answer field below (ctrl + c to copy) (ctrl + v) to past it into the text

25. Upload your in-game data here *



For SurveyCircle users (www.surveycircle.com): The Survey Code is: QNGB-8TN5-NUFL-ZTHJ Or Redeem Survey Code with one click: https://www.surveycircle.com/QNGB-8TN5-NUFL-ZTHJ

Dette indhold er hverken oprettet eller godkendt af Google.

Google Analyse

P10 - Master's Medialogy Project

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Firstly, you will go through the consent form and demographic info, and then you will download the zip file containing the game. You don't need to install anything, so you need to click on the .exe file to run the game. We prefer that you have both the questionnaire open alongside playing the game. Once you finish the game, you can go back and answer the questionnaire. Enjoy!

*Skal udfyldes

1. Consent Form - This test will involve a gaming prototype made by a Master Thesis Medialogy group at Aalborg University in Copenhagen. The test will collect the data from the questionnaire, and record your position and path inside of the game, in order to see behavioral patterns. Please allow the game to be played through your firewall. The data being gathered will be kept for 3 years, sorted out, and will not be published to the public in any sort of way. Your answers will be anonymous throughout the study and only be referred by an ID number. You are allowed at any point to withdraw from the test. This test is for study purposes only. If you have any other questions you can contact one of the study coordinators through this mail: tlaur17@student.aau.dk *

   Markér alle, du er enig i.

   ☐ I agree to participate in the experiment

2. Alias - please write an alias, you can use if you want to retract your data *

3. Gender *

Markér kun ét felt.

- ◯ Man
- ◯ Woman
- ◯ Nonbinary
- ◯ Prefer not to answer
- ◯ Andet: _____

4. Age *

_____

5. Please choose what type of player you find yourself being like when playing a game *

Action "Boom!"	Social "Let's Play Together"	Mastery "Let Me Think"	Achievement "I Want More"	Immersion "Once Upon a Time"	Creativity "What If?"
Destruction Guns. Explosives. Chaos. Mayhem.	Competition Duels. Matches. High on Ranking.	Challenge Practice. High Difficulty. Challenges.	Completion Get All Collectibles. Complete All Missions.	Fantasy Being someone else, somewhere else.	Design Expression. Customization.
Excitement Fast-Paced. Action. Surprises. Thrills.	Community Being on Team. Chatting. Interacting.	Strategy Thinking Ahead. Making Decisions.	Power Powerful Character. Powerful Equipment.	Story Elaborate plots. Interesting characters.	Discovery Explore. Tinker. Experiment.

Markér kun ét felt.

- ◯ Action
- ◯ Social
- ◯ Mastery
- ◯ Achievement
- ◯ Immersion
- ◯ Creativity

6. Select the average number of hours you play video games per week *

Markér kun ét felt.

- ◯ None
- ◯ Less than 1 hour
- ◯ 1 - 3 hours
- ◯ 4 - 9 hours
- ◯ 10+ hours

7. How good would you say your sense of direction is where 5 is very bad and 1 is very good

Markér kun ét felt.

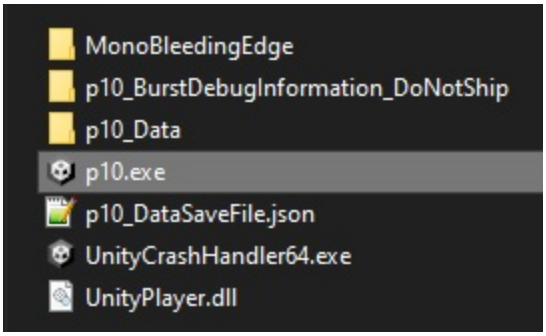
	1	2	3	4	5	
Very good	◯	◯	◯	◯	◯	Very bad

Download the game

Please follow the link to download the prototype game:

Windows: https://drive.google.com/file/d/1IsFZEx-OsaReXg4RhwrE-EfQgJkBc1Ek/view?usp=sharing

Once you have downloaded the game, please extract/unzip the file you have downloaded and play the file. Please wait until you are finished with the game before filling out the next parts of the questionnaire.



8. Have you downloaded the game? *

Markér kun ét felt.

- [ ] Yes

Post game questionnaire

9. How complex do you feel the layout of this town was? Where 5 is very complex and 1 is not complex at all *

Markér kun ét felt.

	1	2	3	4	5	
Not complex at all	◯	◯	◯	◯	◯	Very complex

10. How confident are you in that you would be able to draw a sketch of the town? * Where 1 is not confident at all and 5 is very confident (You do not have to draw the actual sketch)

Markér kun ét felt.

	1	2	3	4	5	
Not confident at all	◯	◯	◯	◯	◯	Very confident

11. Would doing such a sketch of this town be difficult or easy? (Don't worry about your own degree of 'artistic' ability) *

Markér kun ét felt.

	1	2	3	4	5	
Very easy	◯	◯	◯	◯	◯	Very difficult

12. How accurate would you be of the town sketch you'd have drawn? *

Markér kun ét felt.

	1	2	3	4	5	
Very poorly						Very accurately

13. My sketch would represent the arrangement of the town... *

Markér kun ét felt.

	1	2	3	4	5	
Very poorly						Very accurately

14. How many different areas of the town would you have drawn, and what would you have called them? *

15. How difficult did you feel it was to navigate in the town? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult						Very easy

16. How difficult was it to find the laundry place in this town, as shown on the image? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult	◯	◯	◯	◯	◯	Very easy

17. How difficult was it to find the spirit near the lamppost on the street behind the market place, as shown on the image? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult	◯	◯	◯	◯	◯	Very easy

18. How much do you agree with the following statement: Each area gave me a different feel? Where 1 is disagree and 5 is agree *

Markér kun ét felt.

	1	2	3	4	5	
Disagree	◯	◯	◯	◯	◯	Agree

19. How often did you feel lost while playing the game? Where 1 is all the time and 5 is never *

Markér kun ét felt.

	1	2	3	4	5	
All the time						Never

20. How accurate do you remember the five places where there was the circle of flowers was placed in the entire town? Where 5 is very accurately and 1 is not at all *

Markér kun ét felt.

	1	2	3	4	5	
Not at all						Very accurately

21. How difficult do you think it would be to direct another player through this game? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult						Very easy

22. Did you find this town a relatively easy or a relatively difficult place to “figure out”? Where 1 is very difficult and 5 is very easy *

Markér kun ét felt.

	1	2	3	4	5	
Very difficult						Very easy

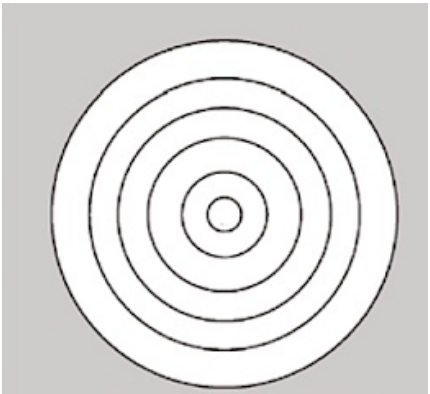
23. The layout of each area was predictable. Where 5 is very predictable and 1 is very unpredictable *

Markér kun ét felt.

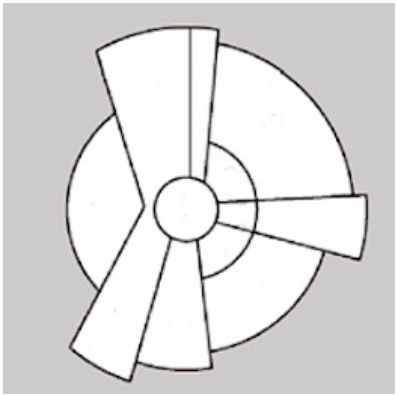
	1	2	3	4	5	
Very unpredictable	◯	◯	◯	◯	◯	Very predictable

24. Which one of the images below best represents the layout of the town? *

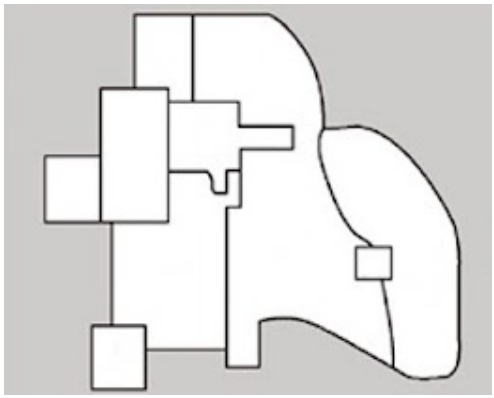
Markér kun ét felt.



◯ Layout A



◯ Layout B

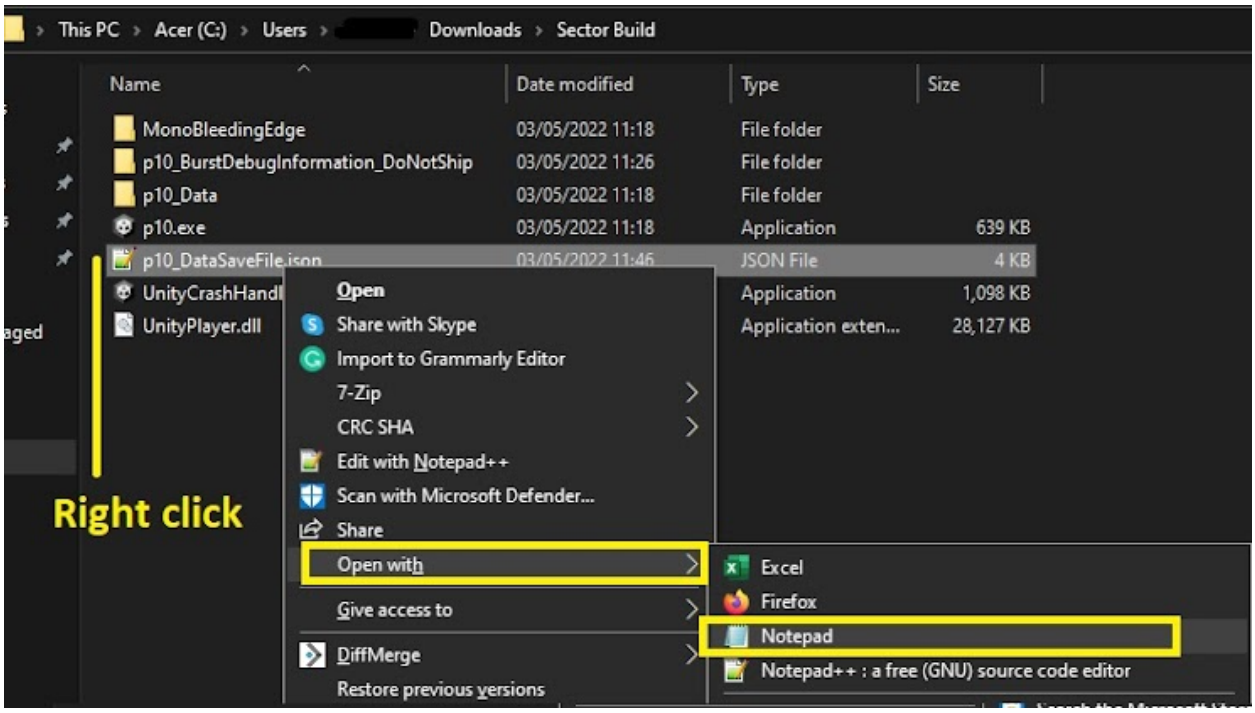


◯ Layout C

Upload In-game data

Please go to your game folder and go to your p10__Data folder and find the .json file, open the file and copy-paste the entire text of the file into the answer field below (ctrl + a to mark all text) (ctrl + c to copy) (ctrl + v) to past it into the text field below

25. Upload your in-game data here *



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