Interaction Design and Architecture(s) Journal - IxD&A, N.65, 2025, pp. 236 - 256
DOI: 10.55612/s-5002-065-008

Towards New Spatial UI Metaphors: Exploring Mediterranean Architecture in Game Environment Design

Feyza Nur Koçer-Özgün [1], Sema Alaçam [1,2],

[1] Architectural Design Computing Program, Istanbul Technical University, Istanbul, Turkey
[2] Faculty of Architecture, Istanbul Technical University, Istanbul, Turkey
kocerf@itu.edu.tr

Abstract. This study investigates the ability of Mediterranean architectural values to inspire the development of new spatial user interface (UI) metaphors. We examine Mediterranean-themed video games to analyze existing spatial user interface metaphors. Based on these insights, we propose a framework for developing metaphors that integrate these architectural principles into video game interfaces, thereby promoting cultural awareness and increasing user engagement. Through the heuristic evaluation steps used to refine the metaphors we analyzed and developed thematically, we also established a set of criteria for evaluating spatial UI metaphors in gaming environments. This research contributes to HCI and game design by providing a framework for embedding and assessing architectural concepts in spatial user interface metaphors. Our study aims to support designers in creating interactive environments that leverage players' spatial prior knowledge through metaphors, while simultaneously preserving and celebrating architectural narratives of the Mediterranean region.

Keywords: Spatial UI metaphors, Mediterranean architecture, User interface, Video games, HCI metaphors

1 Introduction

The user interface (UI) plays a central role in maintaining narrative continuity in video games. The graphical representations on the UI used in the game design process are also where the game story becomes spatially connected to the player [1]. The spatial metaphors used in the interface define non-linear spatial relationships depending on time in the game story and create navigation cues [2]. The designer adopts the player's perspective for the exploration of the game world and creates metaphorical productions through routes and scenarios that he can use to reach the goals. Reflecting real-world spatial and architectural elements in the design of the game environment in a way that is compatible with the game story supports smooth and intuitive interaction with the player. Depending on the period in which the game takes place, interface depth is enhanced using tools such as maps and compasses. Additional information about the narrative may be conveyed through character dialogue or textual elements.

Architectural cues in the interface guide navigation while simultaneously enriching the game's narrative and thematic coherence.

Architecture, which can be considered as a set of environmental and spatial storytelling interactions in the real world [3], is inherently spatial, encouraging interaction while exploring. In the game design process, the effect of architecture on the player's interaction with spatial storytelling is not only the use of buildings as a representation tool in the digital environment. In his study discussing how games will approach architecture, Götz [4] states that simply copying buildings and transferring them to the game environment overshadows the potential of the game environment that can be created. Being able to integrate the aesthetic, functional, and cultural concerns in architecture into the game's environmental design without losing them enhances the designer-player dialogue in the game story. The game's environmental design is made by the game's storytelling. To minimize disruptions between the user's physical environment and the virtual experience, recent research has increasingly focused on how virtual elements can be designed to interact meaningfully with users in ways that align with narrative structure and experiential coherence within digital environments [5, 6, 7]. According to Jenkins [8], the role of the game designer extends beyond narrative delivery; they also craft spatial environments where even intricate storylines can unfold in a visually engaging and cognitively accessible manner. All these elements represented create a motivation to progress in the game environment [9]. In the environmental design of video games, context and narrative used in the atmosphere and background details play a critical role in creating meaningful and immersive integrity with the game story. Immersion references the transformation of the player's simulated movements in the game space represented in the interface into a convincing narrative and the game characters' ability to interact between multiple layers [10]. This narrative is conveyed to the player through environmental design, and the player transforms from a passive observer to a character who actively interacts with the narrative [8]. Instead of giving the player information about the subject of the story in the game, the designer's effort to convey this through the elements in the interface adds depth to the game and enriches the UI. For example, the game environment, where architectural elements containing traces of past events are scattered, allows the player to interact with the historical context of the game narrative. By moving beyond static textual storytelling that requires the player to read passively, the designer can employ the game environment as a metaphorical narrative tool, guiding the player's spatial navigation to reveal meaning.This study aims to address the gap in culturally diverse user interface metaphors by investigating how Mediterranean architectural principles can be used as spatial UI metaphors in game design. Integrating these architectural elements characterized by multi-layered cultural narratives, historical depth and aesthetic values into game interfaces through metaphors enriches the dialogue between the designer and the player, as well as the player's interaction with the interface. Within the scope of this study, we investigate spatial UI metaphors that can be used in the game design process by taking inspiration from the architectural elements of the Mediterranean region, which stands out with its rich architectural heritage.

The Mediterranean, which encompasses a wide geographical area extending from the ancient Egyptian, Greek, Ottoman, and Renaissance periods to modern times [11], creates a rich and unique spatial perception with the exchange and regional reinterpretation of the multilayered cultures and architectural traditions of these

surrounding regions. Rather than a fixed architectural form and aesthetic understanding, Mediterranean architecture [12], influenced by these rich layers, has maintained its continuity by developing over time in the center of three continents with the originality of the regions, cultural and historical heritages, and social diversity [11]. The hierarchical spatial organization of the Roman tradition, columned public buildings, amphitheaters, and aqueducts [13], complex multi-dome structures emphasizing the magnificence and importance of the interior in Ottoman architecture, which was also influenced by Byzantine architecture, transformed geometric forms in courtyards and ornaments [14]. This intercultural and multi-temporal Mediterranean architecture also provides an important ground for storytelling and strategic game fiction in video games. In these games, Mediterranean architecture provides an aesthetic background, as well as a navigation and narrative tool that embeds cultural meaning and spatial logic into game mechanics.

By analyzing existing Mediterranean-themed video games, we propose a metaphor generation framework that evaluates architectural and cultural depth, assisting designers create interactive environments for players. While the analyzed video games contain a Mediterranean theme, we argue that Mediterranean architectural elements used in their environmental designs are also a fruitful source of inspiration for metaphors. We applied heuristic evaluation to test our theoretical framework and refine the emergent metaphors. The framework is intended to enrich the designer-player interaction within Mediterranean-themed environments while contributing to broader discussions on culturally rooted interface design.

Our current literature review points to the scope of spatial metaphors in-game interfaces. However, there remains a notable gap in the literature on spatial metaphors inspired by Mediterranean architecture. While metaphors [15, 16, 17, 18] and architectural storytelling [2, 3, 19] have each been explored independently within game studies and HCI, few studies have addressed how culturally grounded architectural systems can be systematically translated into interface metaphors. This study addresses that gap by combining metaphor theory, architectural history, and game environment design into an integrated framework. The research extends current metaphor models by embedding cultural specificity and spatial interaction into early design stages.

2 Theoretical Background

2.1 Metaphors in Game Environment

Metaphors in game interfaces, one of the emerging areas in HCI studies that has gained momentum in recent years [15, 16, 20], are frequently preferred by game designers as elements that support player interaction. Conventional UI approaches in video games static icons and map overlays deliver information through abstract symbols positioned in fixed areas of the screen. While functionally efficient, these elements often exist separately from the game environment and may reduce immersion by breaking the visual or narrative continuity [6, 21, 22]. With innovative interface approaches that aim to improve players' immersion in the digital environment, visual elements that are part of the story in the game have also become functional for player interaction. An

important interaction tool that represents these visual and functional aspects in the game story is interface metaphors [23]. Interface metaphors can be used as a design tool to support the creation and discovery of new design concepts [24], and they function as channels for the flow of information between concepts [25, 26]. According to Aarseth [27], even spatiality in virtual environments is metaphorical, as the relationship of the virtual world with the real world is still maintained metaphorically. For the player to play through intuitive and immersive interactions in a world designed in line with the story, the flow of spatial information from the real world to the digital environment is also provided through interface metaphors. Schell [28] states that metaphors are an excellent shortcut preferred by designers to transfer the processes of understanding, discovering, and adapting to the game to the player in the fastest way.

In the analysis of object-based metaphors used to conceptualize the virtual world in games, metaphors such as table, window, and lens come to the fore [17]. These metaphors are useful for drawing on the player's existing knowledge in the game, but for the designer who also aims to ensure continuity in the game story, metaphorical approaches that can be used as interface components should also be considered in the research. Although metaphors mostly use knowledge and experiences gained from the physical world, there may be no direct real-world object to reference, especially in interfaces with a deep storyline, such as video games [18]. With the increasing volume of changing reality dimensions in games, the necessity of predictable and familiar physical world-based metaphors that emphasize navigation in multiple interfaces is mentioned [29]. Khaled et al. [30] state that metaphors in games support the needs of designers while also contributing to expanding the use of game mechanics. When defining the screen borders as the playable area, metaphorical uses of architectural elements are used [19]. Günzel [19] argues that video game spatial structures used in accordance with architectural and urban design principles create a metaphorically immersive experience for the player. As an example of this immersive experience, the player's 'escape' action in the game world actually turns into an exploration of the environmental narrative, and spatial metaphors that allow the story to be reinterpreted also influence the player's subsequent decisions.

The dungeon and labyrinth structures in The Legend of Zelda: Breath of the Wild (2017) provide visual complementarity as an extension of the mythological background, allowing the player to make spatial decisions through the open world map and enabling exploration of the game world. Architectural structures, which play a critical role in supporting the post-nuclear war world narrative in the Fallout series spanning from 1997 to the present, function as narrative metaphors and build a bridge between past and future that allows the player to construct temporal connections. The vertical architectural elements in the Dark Souls series psychologically support the spatial progress of the player in the background with a sense of success and represent environmental elements through a spatial metaphorical approach. In the environmental design process of the game, reality is adapted to the game requirements [19], as an example, the historical place touches in the Assassin’s Creed Series provide a basis for the player’s immersion in the real-world city textures.

2.2 Reflections of the Mediterranean Influence in Video Games

The integration of advanced modeling techniques and the depth of interaction enabled by high-quality three-dimensional environmental visuals have also paved the way for video game technology to be used as a tool for cultural representation. The digital reconstruction of virtual heritage sites and archaeological structures and the representation of social and cultural values from the relevant historical period in this environment are a source of inspiration for video games. Data collected on artistic, historical, and architectural heritage are utilized in-game events that reference past events and cities [31].

One of the recurring themes in games that are historically and conceptually influenced by many different cultures and events is Mediterranean values. The rich cultural history of the region, the diversity in its architectural elements and social structure, and its continuous interaction with other regions have made Mediterranean geography a frequently preferred subject in video games. The richness of historical and mythological stories in the region offers designers a symbolic depth where they can directly refer to these stories in the game environment. Assassin's Creed II (2009), set in Renaissance Italy, features a game environment constructed with the architectural structures of the period. It includes a parkour mechanic that allows players to explore from the back streets of Florence to the rooftops. Assassin's Creed Revelations (2011), on the other hand, conveys its narrative, set in Istanbul as the game environment, to the player through architectural elements that emphasize the cultural identity, atmosphere, and even religious values in the city. The representation of architectural structures such as Hagia Sophia, which have preserved their landmark effect from the past to the present, allows the player to establish a historical connection with the narrative. Total War: Rome II (2013), while standing out as a strategic war game, also takes place in an environment where the Mediterranean climate and geography are at the center. The goal of the game's warm lighting and color scheme is to give players the impression that they are in this area. The game scenario of Rygar: The Legendary Adventure (2002) is based on Greco-Roman mythology and is set on a Mediterranean island. The influence of Greek Mythology in the God of War series and the interaction between mythological figures and historical locations in Assassin’s Creed Odyssey (2018) are also factors that strengthen the player’s immersion. Field of Glory: Empires (2019) is a military strategy game that frequently uses ancient map metaphors as a game set in the Mediterranean region in the classical era. These examples demonstrate the visual and atmospheric expressiveness of Mediterranean elements. However, the role of these environmental elements is often limited to enhancing the visual realism of the game world without supporting to narrative interactivity. Mediterranean architectural structures are typically presented as static visual backgrounds rather than dynamic, interactive components. As a result, these elements serve more as atmospheric decoration than as active tools that engage the player in the unfolding narrative. Another shortcoming is that many games tend to focus primarily on the most recognizable and commercially appealing aspects of Mediterranean culture. Popular themes such as Greek mythology, Roman aesthetics, or Renaissance architecture dominate the narrative and visual design of these games. While these elements are undoubtedly significant and offer strong symbolic and visual appeal, this narrow focus limits the opportunity for a more comprehensive exploration of the region’s cultural diversity.

3 Designer Perspective on the Game Environment: Spatial UI Metaphors

Design ideas transferred from the mind of the designer to the game environment through the UI are supported by spatial functions within the interface. Designers can use spatial layout to organize the geometric forms or conceptual relationships; this may include grouping related components together, using whitespace to separate different sections of the interface, and using visual cues. The sense of spatial navigation allows users to move through and interact with the interface in the design process. Functions such as scrolling, panning, and zooming can be used by designers to explore the interface. In addition, spatial metaphors can be used both to represent design ideas and to convey the game story to the player through game UI. Concepts such as connection, speed, portal, door, and navigation, which are the most used metaphors in accessing the virtual world, are spatial metaphors [32]. The spatial character of these metaphors that form the backbone of online access to the virtual world is an indication that the story and interaction flow in the game is also spatial.

Describing objects in the virtual world as 'miniatures', Mine [33] identifies navigation and manipulation as two powerful techniques for these objects. The user has a miniature world that refers to the real world, and while the objects represented in this virtual world can be manipulated, the user also maintains movement and action through navigation. While digital objects can be manipulated in the space offered by the virtual environment, the designer gains cognitive insight into objects and actions by navigating in this space. The interface metaphors used by the designer in relation to the game story, aligned with the game's narrative and shaped by the player's experience in this UI, contribute to a synthesized narrative structure [34]. Although navigation and exploration during the game depend on the player's instant choices, the designer creates a spatial flow that will support the narrative in the game through the metaphors they employ. One of the roles of the designer when creating a game environment is to provide a balance in the player's immersion experience while providing this flow in the game [28]. To analyze spatial UI metaphors in current games and discuss new potentials for the future, we examine these three topics highlighted as a result of the literature review in more detail in the following sections: navigation, manipulation, and narration.

Navigation. Spatial navigation, one of the prominent forms of interactions in the evolving digital environment [35], offers users a way to interact with the virtual environment similar to interacting with the physical world. This refers to the process of moving and interacting within a three-dimensional or two-dimensional space in an intuitive and natural way. Both the designer and the player use techniques such as moving forward, backward, up, down or left, right, or turning to move in the digital environment, explore the space, and interact with the virtual objects in it. Spatial metaphors are frequently used in interactive narratives to describe the structure of navigation cues and store information in the digital environment [2]. Portals and passages that enable rapid transitions in the game world, along with interface elements such as maps and compasses that support orientation, are among the most commonly used spatial metaphors in the context of navigation.

Manipulation. In a digital environment, spatial manipulation is multimodal and can affect both the object and its surrounding environments. Actions such as navigating, moving, or even flying in a virtual environment are supported by display functions rendered on a two-dimensional screen. In different studies, manipulation is categorized under three headings: selection, translation, and rotation [36, 37]. In addition, transformation and scaling are often included as basic object manipulation techniques in digital environments [38]. These functions, which constitute the main manipulation framework of modeling-based studies in a computer environment, include separating objects in the virtual environment from each other and changing their position and location. On the player side, manipulation implies direct interaction with objects and spaces. The way in which virtual objects behave according to real-world physical laws and provide feedback to the player represents a metaphorical form of manipulation. Viewport manipulation, which includes various methods such as panning, rotating, and zooming, makes it easier for both the designer and the player to interact with and move around the virtual environment. The camera function within viewport modification can itself be interpreted as a metaphor. Camera-derived functions, which can be used for animation, exploration, manipulation, and presentation purposes, can define a virtual path and guide users through the environment along that trajectory [39].

Narration. Digital representations where navigation and narrative become spatially related [1] help construct the relationship between the environment and the story in video games. Players explore the game environment using navigation metaphors. During this exploration, narrative information is presented through the environment itself [2]. Interface components spatially integrate the story into the game environment, allowing the narrative to unfold continuously throughout gameplay [9]. In the game Dead Space (2008), the design of health information directly on the character costume, rather than as a static component in the interface, transforms this narrative metaphor into a tool that increases the depth of the story.

Unlike physical space, spatial metaphors often transcend singular functions in digital environments. While our framework distinguishes between navigation, manipulation, and narration metaphors for analytical clarity, these roles frequently overlap during gameplay. For example, a temple structure might function as a navigational landmark, a narrative anchor tied to myth or history, and a manipulable interface element if used as a mission hub. The flexibility of digital space enables designers to blend these roles creatively, also calls for intentional clarity to avoid cognitive overload. As such, these three categories should be seen less as rigid divisions and more as thematic lenses for thinking through interaction design within immersive, metaphor-rich environments.

3.1 Exploring Mediterranean Architecture Effect on Spatial UI Metaphors

Aiming to create a basis for discussing spatial UI metaphors in the context of game interfaces, three video games inspired by Mediterranean culture and geography were selected: Hegemony III: Clash of the Ancients (2015), Assassin's Creed Odyssey (2018), and Field of Glory: Empires (2019). In these video games, there is a

Mediterranean geography extending from the Hellenistic period to Rome and Greece, including the Aegean Sea and the surrounding islands. Common criteria were determined in the selection of these games and games rich in metaphor and open to spatial exploration were preferred. These games were selected for their high suitability to support in-depth interface analysis, using core criteria grounded in game studies and digital humanities theory. The first criterion was that historical and cultural depth had rich content related to the Mediterranean region. This context is important because it provides a narrative and aesthetic foundation for spatial UI elements and allows analysis of how such metaphors are embedded in culturally significant environments. Secondly, architectural elements reflecting the Mediterranean region were used intensively in the digital environments of the selected games. Architecture in games serves as a visual background and as a trigger for spatial interactions. Metaphors that can be produced for navigation, manipulation, and storytelling are fed by these architectural elements. Finally, genre diversity was also a key consideration. The selected games offer varying modes of interaction with the game environment and include a variety of interface metaphor types such as control units, maps, and visual indicators. Each type emphasizes different types of player interaction and provides unique insights into how spatial UI is implemented.

Each game offers a different perspective on the Mediterranean world. Reflecting the settlement patterns of the classical Mediterranean cities and nourished by early Roman and Italian architecture, the historical focus of Hegemony III: Clash of the Ancients is the competition between various groups living together before the empire. The effect of city structures and road networks on strategic decisions makes it possible to observe spatial metaphors directly within the game geography. Assassin's Creed Odyssey, on the other hand, presents a geography extending from Attica to the Aegean islands, reflecting the Hellenistic cultural structure and the settlement of Classical Greece. The player's movement interacts with the storytelling, and the architecture is shaped by the spatial layout of the Greek poleis, amphitheaters, various sacred areas and temples with cultural value. Another selected game, Field of Glory: Empires, covers the Mediterranean in a broader context and includes the interaction of different Mediterranean civilizations in the geography extending from Rome to Egypt and the Near East. The city layers in the game, advanced trade networks, and regional relations provide a rich infrastructure for the representation of spatial metaphors. The three selected games offer a rich source for spatial metaphors inspired by this geography with their handling of cultural, historical, and architectural values of different Mediterranean civilizations.

Understanding spatial UI metaphors in the interfaces of games that incorporate Mediterranean values is addressed through the analysis of the digital environment designed for gameplay. As shown in Figure 1, spatial metaphors act as a bridge between the player and the designer in the actual interface.

DOI: 10.55612/s-5002-065-008

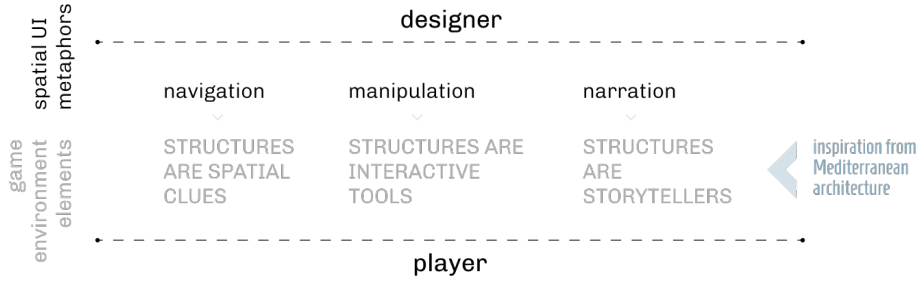

Fig. 1. Representation of spatial UI metaphors on game environment and integration of Mediterranean architecture into the design process.

Metaphors in games use architectural features, cultural and historical aspects to enhance the gaming experience and create a meaningful connection between the player and the game world. Structures such as temples, statues, and lighthouses, closely associated with Mediterranean architecture, are especially prominent as navigation metaphors functioning as iconic and functional landmarks. For instance, Mount Taygetos in Assassin's Creed Odyssey provides intuitive guidance to players with its high dominant position in the region where it is located and the Colossus of the Naxians represents the giant statue outside the Temple of Apollo. These landmarks, which are compatible with geography, have the ability to play a remarkable role in the interface both functionally and aesthetically in order to increase immersion in the game narrative. Large-scale structures such as amphitheaters, ports, and aqueducts reflecting Mediterranean architecture are implicit metaphors for the in-game character and geography connection. For example, the amphitheater within the game narrative is not merely a visual part of the game environment, it represents the cultural influence of the game population. The player can make strategic decisions according to the location and development of such structures and can benefit from them for manipulations in the environment. A manipulation involving the size, location, or function of environmental structures open to interaction can have an abstract but dynamic effect on the game mechanics. Narration metaphors, which are used to spatially strengthen the game storytelling, play an important role in conveying different narrative layers in the games to the player. In Hegemony III: Clash of the Ancients, the city layout and fortifications tell the evolution of regional control and strategic dominance in the Mediterranean basin. In Field of Glory: Empires, trade routes represent the spaces where economic and cultural exchanges that sustain and enrich civilizations take place. The establishment and maintenance of these routes also tell the player stories about the prosperity, alliances, and spread of ideas in the region. These architectural elements go beyond serving as static backgrounds and they immerse players in the historical and cultural context, becoming storytelling tools through which the designer actively engages with the player.

4 Research Design: Towards New Spatial UI Metaphors

With the developing technology, the developments in software and hardware of digital interfaces affect the mental and physical habits and digital experiences of both designers and players. Current interfaces incorporate components such as viewports for mouse or keyboard navigation in 3D environments, along with camera and scene metaphors, object-oriented paths, and transformation tools, each supporting effective exploration and manipulation within virtual spaces. However, in order to think of new interface tools that will support the designer's spatial actions in the game world and also the design action, it is first necessary to determine the needs and goals behind these tools. Because the player's spatial exploration of the game environment is also based on in-game goals and narratives [27]. The game narrative that forms the common understanding of the designer and the player and the collaboration in the digital environment is established through metaphors [30]. All these changes in the interaction established with the digital game environment are signals of the emergence of new UI metaphors.

The research of Carroll and Thomas [40] is one of the pioneering studies on metaphors to be developed for HCI, and they emphasize the importance of selecting metaphors that offers comprehensive semantic integrity when developing metaphors and choosing exciting metaphors even for ordinary tasks. Madsen [41] stated the necessity of building new metaphors on top of preexisting ones by citing three fundamental steps in the metaphor-development process: design, production, and evaluation. As a first step, it is necessary to discover how the user understands the system and current metaphor usages [41, 42, 43]. This stage provides an opportunity to reconsider existing implicit metaphors in a comprehensive exploration of the relationship between the focused interface function and the user [41]. Creating comprehensive and various metaphor alternatives, and analyzing, and evaluating these metaphors also play an important role [41, 42, 44, 45]. During the evaluation process, building the story of the metaphor [44], marking missing points and contradictory parts [41, 43], and receiving feedback on the design of the metaphor [42] are also steps that strengthen new metaphors.

A qualitative heuristic approach was followed in this study to identify and expand spatial metaphors. The analysis of the selected games was conducted using a heuristic framework, drawing on conceptual metaphor theory [25], to identify Mediterranean architecture in these games. Each game environment was examined through close visual analysis to identify Mediterranean-inspired architectural elements. These elements were then interpreted as spatial metaphors, which were categorized according to three primary functions: navigation, manipulation, and narration. The metaphors were evaluated using heuristic criteria based on cognitive resonance, narrative placement, and interface clarity, following established models in usability and player experience research. This approach allowed for a flexible yet structured interpretation of how Mediterranean architectural forms shape digital space and interaction in video game design and offered an insight into the role and value of metaphors.

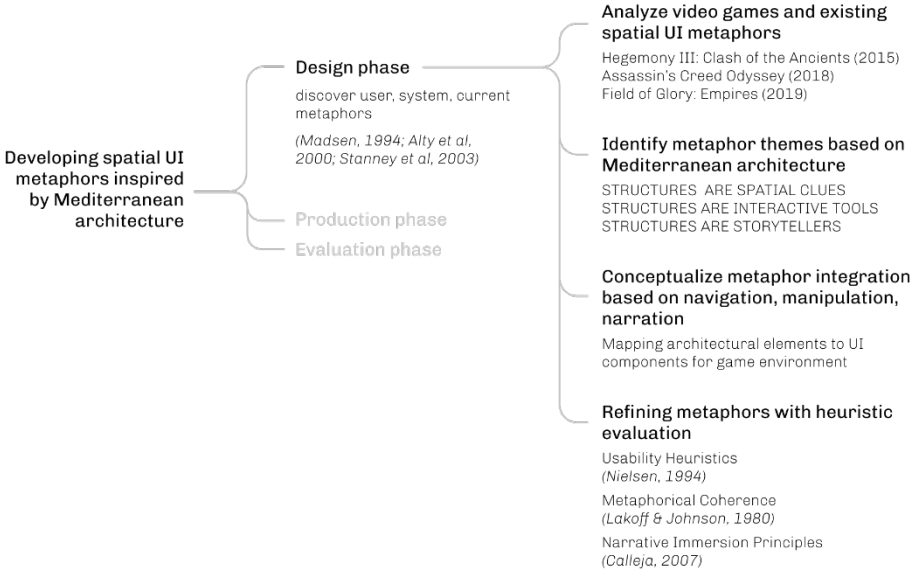

Fig. 2. Methodological framework followed within the scope of the research.

The diagram in Figure 2 shows the framework for the metaphor development process in this study. Although the metaphor development process in the context of HCI is extensive, understanding the existing system, user and metaphors is key to discovering the potential metaphors that can be developed. In this study, we first aimed to address spatial UI metaphors in games that incorporate values rooted in Mediterranean geography. As part of the conceptualization step, we reinterpreted the metaphor themes identified through this analysis to integrate metaphors into the game environment. While the production and evaluation phases are essential components of a holistic HCI metaphor development process, they are beyond the scope of this study.

The metaphor conceptualization framework, developed based on the subject whose theoretical framework was detailed in the third section, constitutes the final step of the metaphor designing for game interfaces in the context of HCI.

4.1 Conceptualizing Metaphor Integration

The metaphor conceptualization framework that highlights the scope of Mediterranean architecture to enrich spatial user interface design by blending cultural depth with game functionality is given in Table 1.

Table 1. Emerged metaphors from the selected video games.

Game	STRUCTURES ARE SPATIAL CLUES	STRUCTURES ARE INTERACTIVE TOOLS	STRUCTURES ARE STORYTELLERS
Hegemony III: Clash of the Ancients (2015)	**Terraces** Cascading menu structures reflecting layered progression in gameplay **City layouts** Strategic positioning of cities on the game map	**Fortifications** Directly manipulating defenses to protect against invasions **Courtyards** Centralized UI organizes functions like army management or trade networks	**Watchtowers** Layered defense metaphors visualize territorial control and threats, narrating historical conflicts **Ruined cities** Abandoned towns as visual markers of past conquests
Assassin's Creed Odyssey (2018)	**Labyrinth streets** Mini-maps designed as maze-like structures **Fishing villages and harbors** Navigational hubs for maritime trade across the Aegean Sea **Colonnades** Rows of pillars in temples guide players toward specific objectives	**Domes** Skill trees visualized as domes **Aqueducts** Symbolizing resource management tied to Mediterranean infrastructure **Mosaics** Organizing items within grid-based systems inspired by mosaic patterns	**Amphitheaters** Circular zones reflecting cultural growth **Temples** Murals in temples narrate mythological stories
Field of Glory: Empires (2019)	**Olive Groves and Terrains** Branching pathways to symbolize decisions	**Sunlit arcades** Dynamic lighting effects to emphasize control	**Floor patterns** Reflecting the growth of cities, narrating the civilization's expansion

Based on the games selected for analysis, the metaphors STRUCTURES ARE SPATIAL CLUES, STRUCTURES ARE INTERACTIVE TOOLS and STRUCTURES ARE STORYTELLERS discussed in the third section align directly with the spatial UI metaphor contexts focused on navigation, manipulation, and narration, respectively. The STRUCTURES ARE SPATIAL CLUES metaphor reflects structures and environmental elements that facilitate navigation in the game world. An example of this metaphor is the lighthouses that help players find their way, especially in maritime navigation, and also reflect the historical importance of Mediterranean trade routes. Temples and statues on maps provide clear reference points for players, acting as a visual compass in the game's story world, which can vary at different scales and often covers a large area. Structures such as city landmarks and coastal ports intuitively communicate trade routes and the strategic importance of resources to players. These structures, which provide navigational cues, also affect movement and

decision-making processes in the game's multilayered narrative and designed environment. The STRUCTURES ARE INTERACTIVE TOOLS metaphor refers to players interacting directly with structures in the game world. Structures such as fortifications and marketplaces help players manipulate strategic resource management and territorial control. Amphitheaters and aqueducts provide control of resources and become tools that players use to expand their spheres of influence. These structures directly affect the player's manipulations based on their in-game strategy. The STRUCTURES ARE STORYTELLERS metaphor treats structures as part of the in-game narrative, allowing players to learn the story from the physical world around them. Murals and engravings in the game environment can provide historical and cultural context to players through mythologically informed stories, allowing them to find traces of mythological figures or historical events as they explore ancient ruins.

Labyrinthine street patterns, often seen in ancient Mediterranean port cities such as Ephesus or Pompeii, reflect Hellenistic and Roman urban planning [13]. Aqueducts, symbolizing logistical flow, are drawn from Imperial Roman infrastructure, where water channels were feats of civil engineering and power projection [46]. Domes and terraces, used here as metaphors for progress and hierarchy, are associated with Byzantine and Renaissance architecture, respectively [14]. Even symbolic metaphors like mosaics and arcades reflect stylistic patterns from Roman domestic spaces and Islamic-Andalusian courtyards.

Navigation metaphors such as labyrinthine streets can inspire minimaps that reveal maze-like layouts as players explore. Winding streets of Mediterranean cities like Mykonos or Dubrovnik evoke the region's urban design principles, fostering a sense of place that deepens the player's understanding of Mediterranean geography and cultural history while enhancing in-game navigation. Fishing villages and ports serve as intuitive hubs for fast travel or trading. Manipulation metaphors such as domed structures can represent skill trees in radial layouts that reflect architectural complexity. Central UI elements such as courtyard-inspired hubs can organize gameplay functions around an interactive, atrium-like interface. Narrative metaphors enhance storytelling by using amphitheaters as visual progress trackers, ruined cities as clickable markers that reveal information, and mosaic-style grids to organize inventory. Ruined cities can be designed as clickable points on a map that trigger pop-ups that reveal historical narratives or unlock side quests. Dynamic lighting inspired by sunlit arcades can highlight active UI elements, naturally drawing the player's focus.

These examples demonstrate that structures are not only aesthetic elements in the game world. They play a critical role in shaping player experience through navigation, interaction, and storytelling. These metaphors integrated into Mediterranean architecture make the gaming experience more intuitive, functional, and culturally rich.

4. 2 Refining metaphors

The heuristic evaluation method was used to strengthen the theoretical basis of the metaphor development framework and to refine the conceptually developed metaphors. Heuristic evaluations are commonly used in HCI studies as they allow rapid and efficient examination of interface elements based on a set of heuristic rules and the evaluation based on in-depth reviews conducted by experts who are very familiar with

both the method and the subject matter [47]. In this study, the heuristic evaluation was conducted by the authors, who have expertise in UI design, interaction in games, and architecture. During the self-guided heuristic review process, we created a set of ten criteria based on Lakoff and Johnson's [25] theoretical framework on metaphors for coherence and cognitive load in the context of metaphors, Usability Heuristics [48] to evaluate the representation of metaphors in the user interface, and Calleja's [10] Spatial Involvement and Narrative Involvement to assess storytelling in game interfaces. Table 2 shows the criteria and related definitions that identify the possible strengths, weaknesses, and opportunities for improvement of each metaphor. These heuristics were chosen specifically to evaluate spatial UI metaphors in the context of culturally rooted design. Unlike the UI component and usability-based evaluation studies in applications, a unified framework was required to evaluate metaphors included in the study, such as clarity, functionality, narrative alignment, spatial exploration, thematic coherence, and maintaining cultural meaning in the game environment. This unified framework allowed for the evaluation of the usability, symbolic value, and spatial narrative affordances of each metaphor.

Table 2. Heuristic evaluation criteria, determined based on [10, 25, 48].

	Heuristic criteria	Criteria definition
Metaphorical Coherence [25]	**(1) Conceptual mapping**	Metaphor effectively maps the game narrative onto the game environment.
	(2) Cultural mapping	Metaphor authentically represents the architectural Mediterranean inspiration
	(3) Clarity and functionality	Metaphor makes interaction intuitive and serves a meaningful purpose within the game
Usability Heuristics [48]	**(4) Visibility of system status**	Metaphor provides feedback in line with the environment and story in the game
	(5) Match between system and the real world	Metaphor aligned with Mediterranean architecture represents its real-world counterpart
	(6) Flexibility and efficiency of use	Metaphor adapts to different game environment or complexity levels
Spatial and Narrative Involvement [10]	**(7) Contribution to the narrative**	Metaphor enhances the game narrative by Mediterranean values
	(8) Thematic consistency	Metaphor aligns with the Mediterranean theme within the game narration
	(9) Navigation and exploration	Metaphor provides spatial cues for navigation and exploration within the game environment
	(10) Interaction through spatial structure	Metaphor provides a spatial structure with which the player can interact with

The relationship between these criteria compiled in line with the content of our research for the systematic evaluation of conceptualized metaphors designed through the Mediterranean-themed games Hegemony III: Clash of the Ancients, Assassin's Creed Odyssey, and Field of Glory: Empires, and the emerged metaphors is shown in Table 3. The metaphors in Table 1 that match the criteria definitions in Table 2 are represented as dots in the intersection cells in Table 3.

Table 3. Evaluation of metaphors according to the heuristic criteria in Table 2.

Metaphors	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Terraces	•	•	•	•			•	•		
City layouts	•	•	•	•	•	•	•	•	•	
Fortifications	•	•	•	•	•	•	•	•	•	•
Courtyards		•	•		•			•		
Watchtowers	•	•	•	•	•		•	•	•	•
Ruined cities	•		•				•	•		
Labyrinth streets	•	•	•	•	•	•	•	•	•	
Fishing villages and harbors		•	•	•	•			•		
Colonnades		•	•	•	•		•		•	
Domes	•	•	•	•			•	•		
Aqueducts	•	•	•	•	•	•	•	•		•
Mosaics			•		•					
Amphitheaters	•	•	•				•	•		
Temples	•	•	•		•		•	•		•
Olive Groves and Terrains		•			•		•	•	•	
Sunlit arcades		•	•		•					
Floor patterns	•	•	•		•			•		

The dots in Table 3 were assigned according to their compatibility with heuristic criteria, considering the functional purpose of each metaphor and its representation within the game design. Conceptual Mapping (1) was used to indicate metaphors like labyrinthine streets, which recall the difficulty of navigation, and aqueducts, which represent the movement of resources. Cultural Mapping (2) was a valid criterion for all metaphors, as they were developed directly from the Mediterranean theme. Only Ruined Cities was excluded as it was a strong metaphor for the game environment, but did not directly reflect the relationship with Mediterranean architecture. Clarity and Functionality (3) were emphasized for metaphors such as Terraces and Domes, which make progress and organization intuitive. Visibility of System Status (4) and Match Between System and the Real World (5) reflect how metaphors such as Watchtowers and Fishing Villages provide feedback and use real-world inspirations. Flexibility and Efficiency of Use (6) were assigned for metaphors like City Layouts and Labyrinth Streets that cater to a variety of game narratives. Contribution to the Narrative (7) and Thematic Consistency (8) were applied to metaphors like Temples and Amphitheatres. These structures, which strongly represent Mediterranean architecture, also offer space for spatial interaction. Metaphors with a more abstract visual interaction, such as Sunlit Arcades and Mosaics, were not assigned to (7) or (8). Navigation and Exploration (9) were prioritized for spatially engaging metaphors like Colonnades. Finally, Interaction Through Spatial Structure (10) was assigned to metaphors that actively interact with

the environment like Aqueducts and Watchtowers, excluding static elements like Terraces or symbolic elements like Mosaics.

The heuristic evaluation highlights that most of the developed metaphors are compatible with Mediterranean values in a narrative context and have the capacity to be integrated into the game interface. Metaphors such as Labyrinth Streets, Aqueducts, and Fortifications stand out in terms of their functional depth, cultural specificity and interactivity. Effective use of these metaphors in the user interface can also support a dynamic and immersive narrative of the game world. City Layouts and Watchtowers are strong metaphors in terms of their versatility and ability to guide navigation, enhance exploration and thematic coherence. However, static or abstract metaphors such as Courtyards and Mosaics have more limited interaction. A more implicit metaphorical approach will be required to integrate them into the game environment in a way that supports the narrative in terms of spatial exploration. In addition, Sunlit Arcades and Floor Patterns perform well visually and thematically, but their integration into the game environment remains limited and these elements lack dynamic storytelling capabilities.

4.3 Unveiling the Value of Spatial UI Metaphors Inspired by Mediterranean Architecture

There are several areas where integrating Mediterranean-inspired spatial UI metaphors into game environments can contribute directly or indirectly. One of the critical advantages is the potential of these metaphors to support digital tool interfaces for cultural preservation. Architectural elements used as metaphors are frequently used in game themes as a strong background narrative in video game design, as demonstrated in the current literature review. The presence of landmarks such as the Temple of Apollo and Mount Taygetos in the Assassin's Creed Odyssey (2018) and the interaction of players with these spaces transforms the player's in-game exploration into an implicit educational experience. The metaphor-focused framework supports the development of understanding of Mediterranean heritage by directly embedding historical events and structures into the game and strengthening the game's narrative.

Another contribution of these enhanced metaphors is the expansion of the communication channel between the game environment designer and the player. The designer’s intentions and the game story are conveyed through metaphors already familiar to the player. In-game metaphorical interface components that encourage the player to move beyond passively experiencing the game and actively engage with the narrative help create a feedback loop between the player and the designer. The way the metaphorical element integrated by the designer is perceived by the player and affects their decisions indicates whether the design has achieved its purpose.

4.4 Limitations

While this study proposes a conceptual framework for integrating cultural and architectural values into spatial user interface metaphors, there are several limitations to acknowledge. First, the developed metaphor themes were only examined in a spatial

context. There are different metaphor approaches based on the Mediterranean region that may enhance the content of the game environment to be designed. In addition to the direct correspondence of architectural elements to a spatial area in the designed environment, language, and cultural elements also create a spatial relationship metaphorically. In their studies examining the relationship of designers with spatial metaphors in the interface during the design process, Pitt and Casasanto mention that language and cultural experiences can also be supported by metaphors that strengthen spatial relationships in the mind. Based on this, they claim that designers should use spatial metaphors that the user will interact with in the UI in order to increase the effective use of the designed space [49]. In this context, we focused on the spatial aspect of UI metaphors at this stage of our study.

Another limitation is that the framework has not yet been empirically tested with user studies involving game designers or players. This limitation stems from the fact that our study primarily focuses on the design phase of metaphors in line with Madsen [41] emphasizing the importance of conceptual consistency before moving on to the production and evaluation phases of metaphor production. Early stage metaphor design utilizes conceptual mapping and cultural grounding before undergoing iterative user testing. Understanding the needs of the interface developed at this stage and enriching the conceptual metaphor alternatives supported by the story behind it are essential before the feedback and evaluation stages [41, 42, 43, 44, 45]. The metaphor development approach in this study is theoretically based and is addressed through heuristic evaluation. The metaphor framework is not intended as a definitive, definitive user interface toolkit. It is intended as a conceptual approach, a tool for ideation, reflection, and cultural integration in early-stage user interface development for video games. Based on these precedents, we aimed to create a basis for more extensive exploration, including empirical validations such as playtests, designer workshops, and co-design sessions, in the further stages of our research.

5 Conclusion

From a designer perspective, enriching spatial UI metaphors with Mediterranean architectural elements offers a compelling opportunity to embed cultural meaning into interactive environments. These metaphors serve as intuitive bridges between real-world spatial logic and in-game mechanics, enriching player experience through familiar architectural cues. Metaphors that align designers' goals and players' expectations create a harmonious balance between functionality and cultural storytelling.

Representing the Mediterranean geography, which provides a culturally and historically rich background for existing video games through interfaces that evolve with new technologies will serve as a digital archive for the preservation and maintenance of the region's valuable resources. Metaphors, as a powerful means to strengthen the interaction with the interface and support the inclusion of Mediterranean values in video games, virtual reality and digital cultural heritage studies, and serious games, offer innovative potential for both usability research and theoretical exploration, due to their direct connection to user experience.

The metaphor development process traditionally includes production and evaluation stages that require user feedback and iterative testing. Instead, our focus was on the design phase, laying the groundwork for future studies to build upon. We used a structured heuristic evaluation to assess the metaphors across three dimensions: cognitive resonance, interactive clarity, and narrative embedding. This form of non-empirical validation allows for a critical but systematic review of how metaphorical architecture functions within interactive environments. The production and evaluation stages, crucial for translating the theoretical and conceptual framework presented here into practical and applied outcomes, remain an area for future exploration.

The adoption of this framework by game designers will also encourage greater incorporation of Mediterranean values into game design. Players who interact with these metaphors will gain insight into the values represented by the region during the game. This approach, now emerging as a subject of game design, can also contribute to the preservation of Mediterranean cultural identity in an increasingly digital environment. Beyond video games, the framework may also extend educational game design, digital cultural heritage, and immersive learning environments. In this context, Mediterranean architectural references can act as tools for informal education, allowing users to encounter historical forms, urban logic, and spatial traditions through immersive interaction. This aligns with emerging research in serious games and virtual heritage environments, which emphasize the role of game-based learning in increasing public awareness of intangible and tangible cultural assets.

This study contributes to the increasing intersection of architecture, interaction design, and cultural heritage by presenting a metaphor-based framework for spatial user interface design inspired by Mediterranean architecture. Although this study focuses on the Mediterranean region as a case study, the underlying approach based on integrating culturally rooted architectural elements into spatial UI metaphors can be transferred and adapted to other cultural and historical contexts. The Mediterranean was chosen due to its rich and layered architectural legacy, however, the framework proposes a transferable methodology for designers aiming to embed local cultural narratives into interactive environments. Designers can similarly leverage spatial storytelling and metaphors to enrich game environments which highlights the potential for cross-cultural expansion of spatial user interface metaphor research and design practice.

CRediT author statement.
Feyza Nur Koçer-Özgün: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review and editing. **Sema Alaçam**: Conceptualization, Supervision

References

1. Drucker, J.: Graphic devices: Narration and navigation. Narrative, 16(2), pp. 121–139 (2008) https://doi.org/10.1353/nar.0.0004
2. Van der Nat, R., Müller, E., Bakker, P.: Navigating Interactive Story Spaces. The Architecture of Interactive Narratives in Online Journalism. Digital Journalism, pp. 1–26 (2021) https://doi.org/10.1080/17512786.2024.2305641

3. Doma, O.O.: Spatio-Temporal Narrative Framework for Architecture in Video Games. In: Lee, N. (ed.) Encyclopedia of Computer Graphics and Games. Springer, Cham. (2018) https://doi.org/10.1007/978-3-319-08234-9_151-1
4. Götz, U.: From Asteroids to Architectoids. Close Encounters between Architecture and Game Design. In: Gerber, A., Götz, U. (eds.) Architectonics of Game Spaces: The Spatial Logic of the Virtual and its Meaning for the Real, pp. 201–214. transcript Verlag, Bielefeld (2019) https://doi.org/10.1515/9783839448021-014
5. Bosman I.D.V.: The role of audio in the diegesis of virtual reality games, in CHI Conference on Human Factors in Computing Systems Extended Abstracts, pp. 1–4 (2022) https://doi.org/10.1145/3491101.3503810
6. Gottsacker M., Norouzi N., Kim K., Bruder G., Welch G.: Diegetic representations for seamless cross-reality interruptions, in IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 310–319 (2021) https://doi.org/10.1109/ISMAR52148.2021.00047
7. Köhle K., Hoppe M., Schmidt A., Mäkelä V.: Diegetic and non-diegetic health interfaces in VR shooter games, in Human-Computer Interaction – INTERACT 2021, 18th IFIP TC 13 International Conference, Bari, Italy, pp. 3–11, Springer International Publishing (2021) https://doi.org/10.1007/978-3-030-85613-7_1
8. Jenkins, H.: Game design as narrative architecture. In: Harrington, P., Frup-Waldrop, N. (eds.) First Person, pp. 118–130. MIT Press, Cambridge (2002)
9. Suter, B.: Narrative patterns in video games: Narrative mechanics and its rules and rule sets. Narrative Mechanics, pp. 51–78 (2021) https://doi.org/10.1515/9783839453452-003
10. Calleja, G.: Digital game involvement: A conceptual model. Games and Culture, 2(3), pp. 236–260 (2007) https://doi.org/10.1177/1555412007306206
11. Zoranić A.: Modern architecture and Mediterranean context, Proceedings – CAUMME, (2012)
12. García Vergara M., Pizza A.: The Mediterranean and modern architecture: The dissemination of a myth in architectural media, The Journal of Architecture, 26(8), pp. 1117–1145 (2021) https://doi.org/10.1080/13602365.2021.1980419
13. Sear F.: Roman Architecture, 1st ed., Routledge (1982) https://doi.org/10.4324/9780203019153
14. Necipoğlu G.: From Byzantine Constantinople to Ottoman Konstantiniyye, in From Byzantion to İstanbul: 8000 Years of a Capital, pp. 262–277, Sabancı University, Sakıp Sabancı Museum (2010)
15. de Oliveira, F.A.: Playing through metaphors: An analysis of metaphor use in life simulation games. Revista de Estudos da Linguagem, 28(2), pp. 871–891 (2020) https://doi.org/10.17851/2237-2083.28.2.871-891
16. Rush, J.: Embodied metaphors: Exposing informatic control through first-person shooters. Games and Culture, 6(3), pp. 245–258 (2011) https://doi.org/10.1177/1555412010364977
17. Kwon, Y.: A Study of Metaphors for Digital Games. Journal of Next-generation Convergence Information Services Technology (2020) https://doi.org/10.29056/jncist.2020.12.02
18. Powell, A.: Composite metaphor, games and interface. In: ACM International Conference Proceeding Series, vol. 123, pp. 159–162. ACM Press (2005)
19. Günzel, S.: Video game spaces as architectural metaphors. In: Metaphors in Architecture and Urbanism: An Introduction, pp. 217–226. transcript Verlag, Bielefeld (2014) https://doi.org/10.14361/transcript.9783839423721.217
20. Stamenković, D., Jaćević, M.: Time, space, and motion in Braid: A cognitive semantic approach to a video game. Games and Culture, 10(2), pp. 178–203 (2015) https://doi.org/10.1177/1555412014557640
21. Fagerholt E., Lorentzon M.: Beyond the HUD, Master of Science Thesis, Department of Computer Science and Engineering, Chalmers University of Technology, Göteborg, Sweden (2009)

22. Ogier H., Buchan J.: Exploring the feasibility of in-game store user interfaces, in Proceedings of the Australasian Computer Science Week Multiconference, pp. 1–10 (2017) https://doi.org/10.1145/3014812.3014881
23. García-Crespo, O., Ramahí-García, D., García-Mirón, S.: From the tool to the spatial metaphor: Graphical user interface and audiovisual creation in new media. Convergence, 27(6), pp. 1696–1713 (2021) https://doi.org/10.1177/13548565211014449
24. Kim, J., Maher, M.L.: Conceptual metaphors for designing smart environments: device, robot, and friend. Frontiers in Psychology, 11, p. 198 (2020) https://doi.org/10.3389/fpsyg.2020.00198
25. Lakoff, G., Johnson, M.: Metaphors we live by. University of Chicago Press, Chicago, IL (1980)
26. Gärdenfors, P.: Mental representation, conceptual spaces and metaphors. Synthese, 106(1), pp. 21–47 (1996) https://doi.org/10.1007/BF00413612
27. Aarseth, E.: Allegories of Space: The Question of Spatiality in Computer Games. Space Time Play, pp. 44–47 (2001)
28. Schell, J.: The Art of Game Design: A Book of Lenses. CRC Press, Boca Raton (2008)
29. Kim, B.Y., Suk, H.J.: A case study on metaphor forms of user interface in HMD-based virtual reality FPS games. Journal of Korea Game Society, 18(1), pp. 27–38 (2018) https://doi.org/10.7583/JKGS.2018.18.1.27
30. Khaled, R., Nelson, M.J., Barr, P.: Design metaphors for procedural content generation in games. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1509–1518. ACM, New York (2013) https://doi.org/10.1145/2470654.2466201
31. Ecorys, KEA.: Understanding the value of a European video games society. Publications Office of the European Union. https://doi.org/10.2759/332575 (2023)
32. National Research Council: Learning to think spatially. National Academies Press (2005)
33. Mine, M.: ISAAC: A virtual environment tool for the interactive construction of virtual worlds. UNC Chapel Hill Computer Science Technical Report TR95-020 (1995)
34. Tarnowetzki, L.: Environmental storytelling and Bioshock Infinite: Moving from game design to game studies (Doctoral dissertation, Concordia University) (2015)
35. Kratky, A.: Metaphor and storytelling in interface design for virtual reality. In: International Conference on Universal Access in Human-Computer Interaction, pp. 287–300. Springer, Cham (2016) https://doi.org/10.1007/978-3-319-40244-4_28
36. Bowman, D., Kruijff, E., LaViola Jr., J.J., Poupyrev, I.P.: 3D User Interfaces: Theory and Practice. Addison-Wesley, Boston (2004)
37. Hrimech, H., Alem, L., Merienne, F.: How 3D interaction metaphors affect user experience in collaborative virtual environments. Advances in Human-Computer Interaction, 2011, pp. 1–11 (2011) https://doi.org/10.1155/2011/172318
38. Mendes, D., Caputo, F.M., Giachetti, A., Ferreira, A., Jorge, J.: A survey on 3D virtual object manipulation: From the desktop to immersive virtual environments. Computer Graphics Forum, 38(1), pp. 21–45 (2019) https://doi.org/10.1111/cgf.13390
39. Roth, D.: Narrative metaphor: Integrating insights in cognitive science into a toolset for intentionally shaping vocational pursuits. International Journal of Christianity & Education, 23(1), pp. 69–80 (2019) https://doi.org/10.1177/2056997118812897
40. Carroll, J.M., Thomas, J.C.: Metaphor and the cognitive representation of computing systems. IEEE Transactions on Systems, Man, and Cybernetics, 12(2), pp. 107–116 (1982) https://doi.org/10.1109/TSMC.1982.4308795
41. Madsen, K.H.: A guide to metaphorical design. Communications of the ACM, 37(12), pp. 57–62 (1994) https://doi.org/10.1145/198366.198381
42. Alty, J.L., Knott, R.P., Anderson, B., Smyth, M.: A framework for engineering metaphor at the user interface. Interacting with Computers, 13(2), pp. 301–322 (2000) https://doi.org/10.1016/S0953-5438(00)00047-3

43. Stanney, K.M., Chen, J.L., Wedell, B., Breaux, R.: Identification of metaphors for virtual environment training systems. Ergonomics, 46(1–3), pp. 197–219 (2003) https://doi.org/10.1080/00140130303521
44. Marcus, A.: Metaphor design in user interfaces. ACM SIGDOC Asterisk Journal of Computer Documentation, 22(2), pp. 43–57 (1998) https://doi.org/10.1145/291391.291397
45. Park, Y.S., Han, S.H., Park, W.K., Cho, Y.S.: Developing User Interface Metaphors for Driver Information Systems. Journal of the Ergonomics Society of Korea, 28(2), pp. 57–67 (2009) https://doi.org/10.5143/JESK.2009.28.2.057
46. Ousterhout R.G.: Eastern Medieval Architecture: The Building Traditions of Byzantium and Neighboring Lands, Oxford University Press (2019) https://doi.org/10.1093/oso/9780190272739.001.0001
47. Lazar, J., Feng, J.H., Hochheiser, H.: Research Methods in Human-Computer Interaction. Morgan Kaufmann, Burlington (2017)
48. Nielsen, J.: Enhancing the explanatory power of usability heuristics. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 152–158. ACM, New York (1994) https://doi.org/10.1145/191666.191729
49. Pitt B., Casasanto D.: Spatial metaphors and the design of everyday things, Frontiers in Psychology, 13, 1019957 (2022) https://doi.org/10.3389/fpsyg.2022.1019957