# HOW TO PLAY WITH MAPS

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# Chapter 1: Introduction

## 1.1 Motivation and Significance: Playful Maps

Video games are a primary form of entertainment today. In 2016, consumers spent 30.4 billion USD on the video game industry and 65% of all households in the United States were home to at least one person who regularly plays video games (Entertainment Software Association 2017). Video games are just one form of gaming and, like non-digital games, are played by people of all cultures, ages, and backgrounds (McLuhan and Gordon 1964/2003, King and Krzywinska 2006, Perkins 2009, Egenfeldt-Nielsen et al. 2013). But, what does it mean to 'play a game,' video or otherwise?

The definitions of 'play' and 'games' are multifaceted and context-dependent (Perkins 2009), drawing from a wide range of fields such as psychology, pedagogy, computer graphics, and new media (Egenfeldt-Nielsen et al. 2013). Across influences, ***play*** generally is described as a voluntary, satisfying (although at times frustrating), and often socially-communicative activity (e.g., Huizinga 1938/2014, Caillois 1958/2001, Avedon and Sutton-Smith 1971, Bateson 1972/2000, Salen and Zimmerman 2003, Lammes and Perkins 2016). Play that gains structure in the form of rules, goals, and conclusive outcomes then becomes a ***game*** (Juul 2003, Salen and Zimmerman 2003, Deterding et al. 2011). ***Gameplay*** refers to the interplay between the rules, mechanics, and geography of the game (Egenfeldt-Nielsen et al. 2013). ***Video games***, also referred to as computer games (Ahlqvist 2011), digital games (Wilmott et al. 2016), or games in virtual environments (Aarseth 2003), then support structured game play through interactive, digital, and highly visual media on a computing device. I adopt these hierarchical definitions of play, games, gameplay, and video games in this research, while acknowledging wider use both conceptually and colloquially.

Most video games—and therefore video game play—are inherently spatial (Aarseth 2007, Jenkins 2004). Video game technology enables virtual realities of imaginary environments, with “the game dynamics emerging from the interplay between rules and game geography” (Egenfeldt-Nielsen et al. 2013: p.121). Video games often provide in-game maps to help players navigate through and make sense of these increasingly complex geographies, facilitating the playful goals of the game. While there are several game genres that differ in required skill and criteria for success (Egenfeldt-Nielsen et al. 2013), the inherent spatiality of video games allows for maps to be applied to any genre of game. Maps in games like Nintendo’s *The Legend of Zelda* franchise (Figure 1.1) have evolved with technology to facilitate increasingly complex video game geographies and gameplay.

Arguably, all mapping is playful, in both creation and use (Kitchin and Dodge 2007, Perkins 2009, Lammes and Perkins 2016) and there are an increasing number of efforts to ***gamify*** geographic, place-based learning by applying tenets of play through interactive user experiences, mobile technology, and augmented or virtual reality (e.g., Armstrong and Bennett 2005, Ahlqvist et al. 2014, Biljecki et al. 2015). For instance, prominent figures in the mapping industry such as Google Maps (2018) and Waze (2018) are gamifying their platforms by offering badges and points as rewards for contributing information. However, traditional cartographic design guidelines are grounded not in play, but in completion of ***work***, or the effort needed to accomplish defined tasks and goals (Landauer 1995). While game structure imposes complex goals and tasks on play, emphasizing work over play privileges user ***productivity***, with the resulting maps designed for optimal efficiency and effectiveness in extracting needed information from the representation (Haklay & Nivala 2010). Such a focus on work and


**Figure 1.1: Nintendo's *The Legend of Zelda* game maps have evolved in detail and purpose along with game complexity and system technology. Starting upper left and going clockwise: *The Legend of Zelda* (1987), *Link's Awakening* (1993), *Breath of the Wild* (2017), *Ocarina of Time* (1998)**

productivity often results in visually complex, informationally-dense maps with minimal embellished marginalia and transparently usable interfaces (Roth 2013b).

In contrast, ***playful maps*** are designed to facilitate not efficiency or effectiveness in map use, but instead competition, entertainment, and fun. Playful maps are often ***interactive***, inviting the user to change information on the map through provided interface controls (Lammes 2008, Lammes and Perkins 2016). Such interactivity can be analog—as with physical game pieces in board games—or digital. In the case of video game maps, the user location often is updated in real time as the player-controlled avatar changes position and orientation. This interactivity cultivates an ***immersive*** experience, situating the user within the map, the imaginary world, and the rules of the playful activity (Greenspan 2005, Fraser and Wilmott 2016, Coulton et al. 2017). Playful maps foster immersiveness largely because they often are intentionally ***incomplete***, encouraging the user to 'co-create' the map as they play (Gee 2003, Lammes 2008, Fraser and

Wilmott 2016). Finally, playful maps are ***inclusive***, serving the socially communicative and collaborative nature of play (Szalavári et al. 1998, Röhl & Herbrik 2008). These tropes of *interactivity, immersiveness, incompleteness,* and *inclusiveness* separate playful maps from maps supporting work, and accordingly lead to different cartographic design decisions regarding the map interface and map representation.

In the following, I use ***traditional cartography*** to describe both static and digital design conventions primarily established to support work productivity rather than play. Table 1.1 lists additional terms used throughout the paper.

## 1.2 Problem Statement and Research Questions

The research reported here responds to the growing calls in cartography to integrate elements of play and games into mapping products and process (e.g., Greenspan 2005, Dormann et al. 2006, Perkins 2009, Ahlqvist 2011, Gekker 2016). Specifically, I investigated video game maps as a case study for enriching traditional cartographic principles with tenets of play. My research examined both the product and process of playful map design through the following questions:

**RQ #1:** *How do video game maps exhibit interactivity, immersiveness, incompleteness, and inclusiveness of playful maps through traditional cartographic frameworks?*

**RQ #2:** *How do video game maps utilize elements of interaction and representation as cartographic tools for play?*

To answer these questions, I conducted a quantitative content analysis (QCA) of 71 playful maps from 50 video games based on their interaction and representation strategies. I coded the maps using established frameworks from cartographic design, including Roth's

**Table 1.1 Terms used throughout this paper that are specific to video game cartography.**

| | |
|---|---|
| ***player-controlled avatar*** | the entity in the video game's virtual world that is controlled by someone in the real-world |
| ***non-player characters*** (NPCs) | entities in the game whose actions are guided and limited to code written into the game (i.e., controlled by the computer) |
| ***primary interaction*** | an interaction where the player (as a map user) directly changes the map through an interactive cartographic interface |
| ***secondary interaction*** | an interaction where the player (as a game user) commits changes in the map through gameplay |
| ***full-sized map*** | a map that takes up the entirety of the screen, disabling all other in-game actions (usually pausing the game) and demanding the player's full attention |
| ***mini-map*** | a map that persists as a part of the heads-up display in a video game interface, typically in the corner of the screen, and does not inhibit in-game actions at all |
| ***active map*** | a map that allows for some in-game actions (e.g., avatar movement) while disabling others and requires the player to divide their attention between concurrent gameplay and map use |
| ***superimposed map*** | a map that is blended with the virtual world where all in-game entities (e.g., avatars, NPCs, etc.) exist; interactions with both map features and in-game entities take place within this map |
| ***diegetic immersion*** | an experience when the player feels immersed in the activity of playing the video game or interacting with a map |
| ***situated immersion*** | an experience when the player feels immersed in the game space and story |
| ***natural metaphor*** | an interaction committed by the player that is analogous to how the player would expect the avatar to interact with a map in the virtual world |
| ***map artifact*** | a map that must be found or created by the avatar in the virtual world before it can be used by the player |
| ***incomplete by extent*** | geographic information about the explorable virtual world is hidden from the player |
| ***fuzzy boundaries*** | distinction between discovered an undiscovered areas in the virtual world by visual variable to communicate that more geographic extent information can be completed through interaction |
| ***incomplete by feature*** | symbols such as the user's location, vantage points, POIs, and NPCs are intentionally omitted from the map |
| ***vantage point*** | a specific in-game position that reveals geography and POIs that immediately surround the vantage point |
| ***symbol discovery*** | interaction where a player commits an in-game action that reveals or resymbolizes points of interest (POIs) or new game information on the map. |
| ***virtual world*** | the rendered game space similar to two- or three-dimensional space in the real world that the player-controlled avatar exists and moves around within (i.e., game space) |
| ***virtual environment*** | the code space of the game that encompasses all elements of the game, including the virtual world and all the menus and interface components |
| ***single-player games*** | games that allow a sole person to control an avatar in the game's virtual world |
| ***multiplayer games*** | games that allow multiple people to control avatars in the game's virtual world |
| ***egocentric map*** | a map that is centered around the user or avatar |
| ***geocentric map*** | a map that is focused on the world or space the user or avatar is within (but not centered on them) |

(2013a) taxonomy of operator primtives for *interaction design* in cartography and Bertin's (1983) visual variables as they apply to *representation design* in cartography (DiBiase et al. 1992, MacEachren 1992). The results of the QCA highlighted areas where video game maps conform to and diverge from cartographic conventions, as well as over- and underrepresented strategies for interaction and representation design. These frameworks also were coded on the purpose of their inclusion according to the interactivity, immersiveness, incompleteness, and inclusiveness of playful maps. The QCA revealed ways in which game maps address novel cartographic problems that have not been encountered in everyday cartography as well as general recommendations for designing maps for play. Accordingly, the results of this study are relevant to cartographers and video game designers alike.

## 1.3 Thesis Organization

The thesis proceeds with four additional chapters. In Chapter 2, I introduce foundational cartographic principles of interaction and representation design, and discuss how the interactive, immersive, incomplete, and inclusive characteristics of playful maps may require us to rethink these conventions for video game maps. Chapter 3 discusses the QCA protocol and its use in cartographic contexts, and details the materials, procedure, and analysis I completed on a sample of 50 video game maps. In Chapter 4, I present the results from the QCA. Finally, Chapter 5 summarizes findings and outlines future directions based on the results of the QCA.

# Chapter 2: Literature Review

Playful maps are included in video games to achieve successful gameplay. These maps exhibit consistent characteristics of being interactive (Section 2.1), immersive (Section 2.2), incomplete (Section 2.3), and inclusive (Section 2.4). Each of the following sections examines how these characteristics of playful maps relate to the dual cartographic principles of interaction design and representation design in video game maps (see Roth 2013a).

## 2.1 Playful Maps Are Interactive

As described in Chapter 1, interaction is one of the defining traits of video games (Juul 2003, Egenfeldt-Nielsen et al. 2013). Interaction is also one of the pillars of digital cartography, referring to when a user changes the map display through a computing device (Roth 2012). Video games and their maps have evolved with similar technology as—but outside the oversight of—traditional cartography (as defined in Chapter 1), both fields utilizing advances in computing power, detailed graphics rendering, and web connectivity (Ahlqvist 2011). However, video games put interactive maps into the hands of the public as early as the 1980s, and thus addressed novel cartographic considerations well before the introduction of Google Maps in 2005 (Greenspan 2005, Lammes and Perkins 2016, Coulton et al. 2017). Fortunately, there are many common linkages between video game maps and traditional cartography focused on work productivity. This section explores the levels of interactivity in video game maps, discussing how interactivity is presented through visual affordances in graphical user interfaces (GUIs) and represented through real-time feedback in game map symbolization.

### 2.1.1 Levels of Interactivity

Cartography recognizes three entities required for digital interaction: the user, the map, and the computing device mediating the dialogue between them (Roth 2013b). These entities fit within broader, non-cartographic frameworks of human-computer interaction, such as Norman's (1988) ***stages of (inter)action*** model as applied to digital interfaces (see Roth 2012). Norman's discrete and observable stages model divides an interaction into steps leading to the execution of the interaction (i.e., how the user speaks to the map, as applied to cartography) and then subsequent steps of evaluation of the interaction outcome (i.e., how the map speaks back to the user), repeating loops of execution and evaluation like a conversation between user and map until the goal has been accomplished, the goal has been abandoned, or a new goal has been adopted. ***Affordances*** are the interface design elements that indicate to the user what the system can do and how it should be used during the initial execution stages of interaction, while ***feedback*** refers to the interface design signals to the user about what happened as a result of the executed operator during evaluation stages of the interaction. While affordances and feedback can be multisensory using sound, haptics, etc., I primarily consider the *visual* affordances and feedback provided through the map display. Visual affordances and feedback are crucial to interactive map design, first ensuring the user knows what interface features are available to change the map (through visual affordances) and then helping the user recognize how the interaction changed the map (through visual feedback). Visual affordances and feedback are similarly important for interactive map design in video games, as together they teach the user how to navigate the virtual environment, manipulate game objects, and ultimately develop a strategy to succeed in the game

All interactions with maps, playful or otherwise, can be deconstructed into a finite number of generic ways that the user can manipulate the map. These ‘building blocks of interaction’ are known as ***interaction primitives***, and they define the solution space for creating and using interactive maps (see Dykes 1997, MacEachren et al. 1999, Crampton 2002, Andrienko et al. 2003, Edsall et al. 2008, for examples). These include ***objective primitives*** (i.e., the basic tasks that the user wishes to complete), ***operator primitives*** (i.e., the basic functionality included in the interface to facilitate user tasks) and ***operand primitives*** (i.e., the basic information or part of the map being manipulated in the interface) (Roth 2012). While tasks and information in maps for play versus work can differ greatly, the operator functionality required to bridge objectives and operands remains largely consistent, allowing operator primitives to be applied to video game map interfaces in the same way as traditional cartographic interfaces. Table 2.1 lists and defines the enabling and work operator primitives of interactive cartography developed by Roth (2013a). There is an established distinction between these two types of operators in traditional maps for work, but it is unclear if this distinction holds in maps designed for play. Therefore, operators listed are not divided according to enabling or work. Figure 2.1 applies many operators from the Roth taxonomy to the map from *Assassin’s Creed III* (Ubisoft 2012).

For interactive maps supporting work, users typically evoke operator primitives using a pointing device (e.g., a mouse, joystick, touchpad) or keyboard (Howard & MacEachren 1996).

**Table 2.1. Roth's interaction operators allow for all known cartographic interactions.**

| Operator | Example |
|---|---|
| ***Import*** | Get started by loading a stock map design of the world |
| ***Export*** | Export the map as a .pdf |
| ***Save*** | Save the map so that you can come back later to make a modification |
| ***Annotate*** | Mark up the map to show where to send resources |
| ***Edit*** | Select a point to change the attribute data |
| ***Reexpress*** | Switch among multiple map representation strategies |
| ***Arrange*** | Arrange a large number of maps for simultaneous comparison |
| ***Sequence*** | Display one time slice after another on the map |
| ***Resymbolize*** | Change the relative sizing of circular proportional symbols |
| ***Overlay*** | Click on the layer panel to show layers of different types of crimes |
| ***Reproject*** | Use alternative projections |
| ***Pan*** | Center the map view on different coordinates |
| ***Zoom*** | Change the scale of the map view |
| ***Filter*** | Perform a query that specifies the range of contaminant concentration levels |
| ***Retrieve*** | Brush over the first district of California to see how people voted |
| ***Calculate*** | Select two cities and calculate the distance between them |
| ***Search*** | Enter search words into Google Maps to find target |

Computer video games also make use of external pointing devices and keyboards, while consoles often have unique gaming controllers that include both pointing devices (e.g., specially joysticks or '+' directional pads) and buttons for special commands. While such work operators are increasingly supported by post-WIMP (Windows, Icons, Menus, Points) designs using touchscreens or even multi-modal input such as voice or gesture recognition (Muehlenhaus 2013), the interaction is applied primarily on an object in the digital environment, such as an interactive map feature or a GUI widget like a checkbox or slider bar. Here, a ***primary interaction*** refers to the direct exchange between user and digital object mediated through a computing device, following Roth (2012).

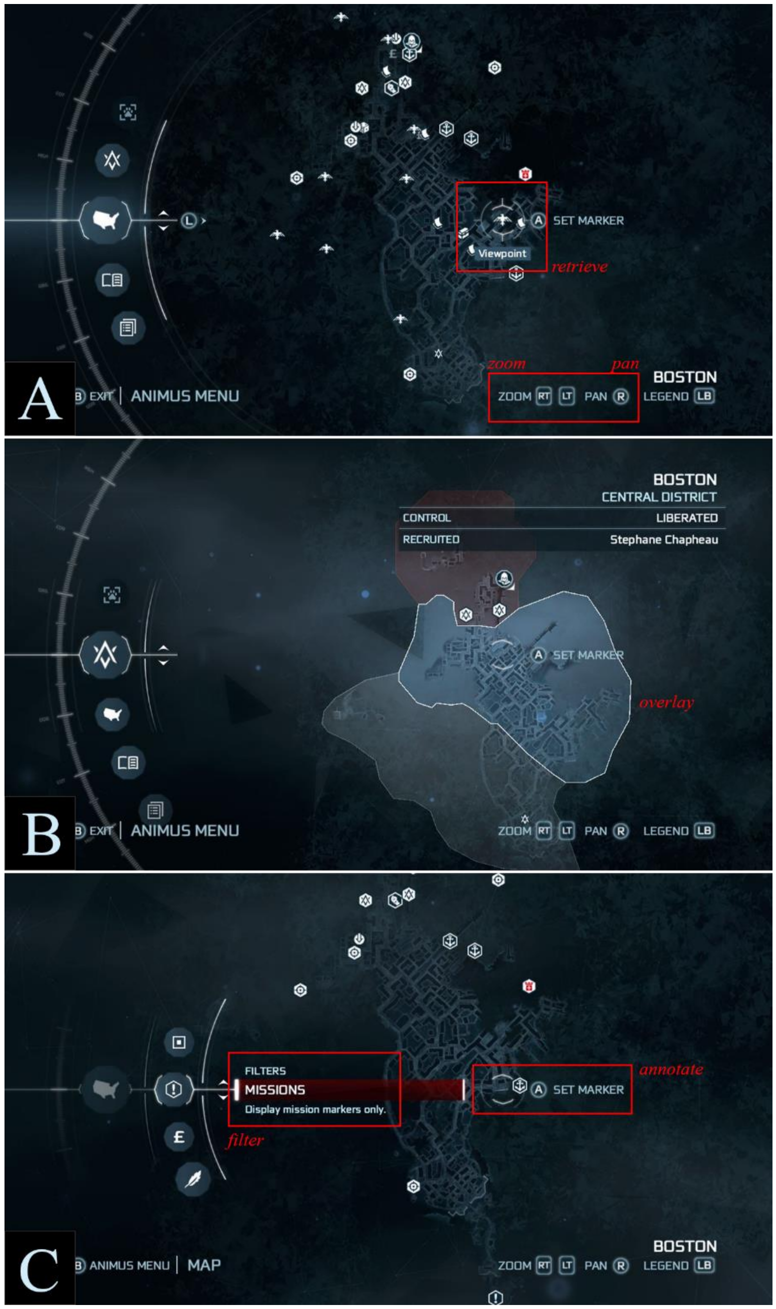



**Figure 2.1: The interaction operator primitives available to the player when using the map from *Assassin's Creed III* (Ubisoft 2012). (A) The user can *retrieve* details about POIs when hovering over them with the cursor. The controls to evoke *zooming* and *panning* allow the user to change the scale and geographic center of the map just as in traditional interactive maps. (B) The user can *overlay* polygons on the map. (C) The user can *filter* map symbols of certain information through the widget on the left side of the screen. The user can also *annotate* the map for future reference or in-game navigation, placing a marker where one does not currently exist.**

Video games also offer a unique method of cartographic interaction via the ***player-controlled avatar***, or the in-game entity controlled by the player that connects them to the virtual world (Filiciak 2003, Waggoner 2009). This avatar acts as an additional entity in the overall cartographic interaction, causing ***secondary interactions*** through the avatar that change the map display and affect gameplay. In other words, the user manipulates the avatar in a primary interaction, with the avatar then manipulating the map in a secondary interaction.

A video game can have both primary and secondary interactions. For example, the video game *The Elder Scrolls V: Skyrim* (Bethesda 2011) affords primary interaction through a cartographic interface, allowing the user to *pan* across and *annotate* the map (Figure 2.2). The game also affords secondary interaction when the player-controlled avatar discovers a new location (Figure 2.3) or gathers information about a new location from a ***non-player character*** (NPC) in the virtual world, visually *overlaying* or *resymbolizing* new symbols to the map. While primary and secondary levels of interaction can coexist in a single game, they are not dependent on one another and can be implemented in tandem to allow the player to strategize during gameplay and complete different tasks. Importantly, secondary, avatar-based interactions are also possible in interactive maps designed for work productivity, such as the “Pegman” avatar in Google Maps used to *retrieve* Google Street View images (Figure 2.4).

Visual affordances for secondary interaction often are similar to how the user’s location is represented on maps designed for mobile devices. When the user moves or changes direction in the real world, the mobile map *resymbolizes* the ***you-are-here*** (YAH) symbol and/or a *reprojection* of the orientation of the map, a strategy described as ***egocentric*** map design, as


**Figure 2.2. An example of primary interaction in *The Elder Scrolls V: Skyrim* (Bethesda 2011). The GUI element (A, highlighted in red and enlarged) shows how the user can "set [a] destination" (i.e., *annotate)* by pressing M1 (i.e., left-click) and creating a marker on the map (B). When the user clicks again (C), a splash-screen appears asking what action the user wishes to do involving their custom marker.**

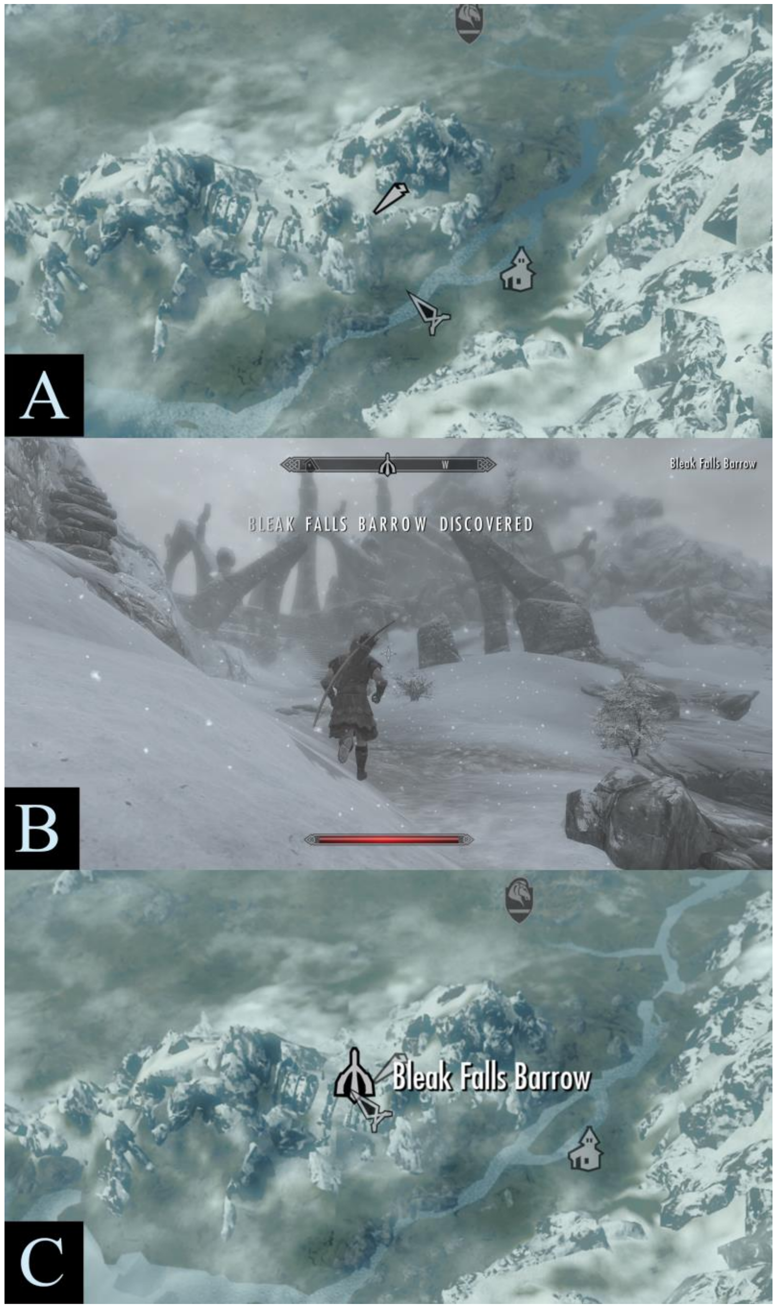



**Figure 2.3. Secondary interaction in *The Elder Scrolls V: Skyrim* (Bethesda 2011) is shown in a sequence. The map is initially void of the symbol for Bleak Falls Barrow (A) until the avatar visits the POI location in the virtual world (B). Once discovered, the POI appears on the map to be referenced at any time during gameplay (C).**

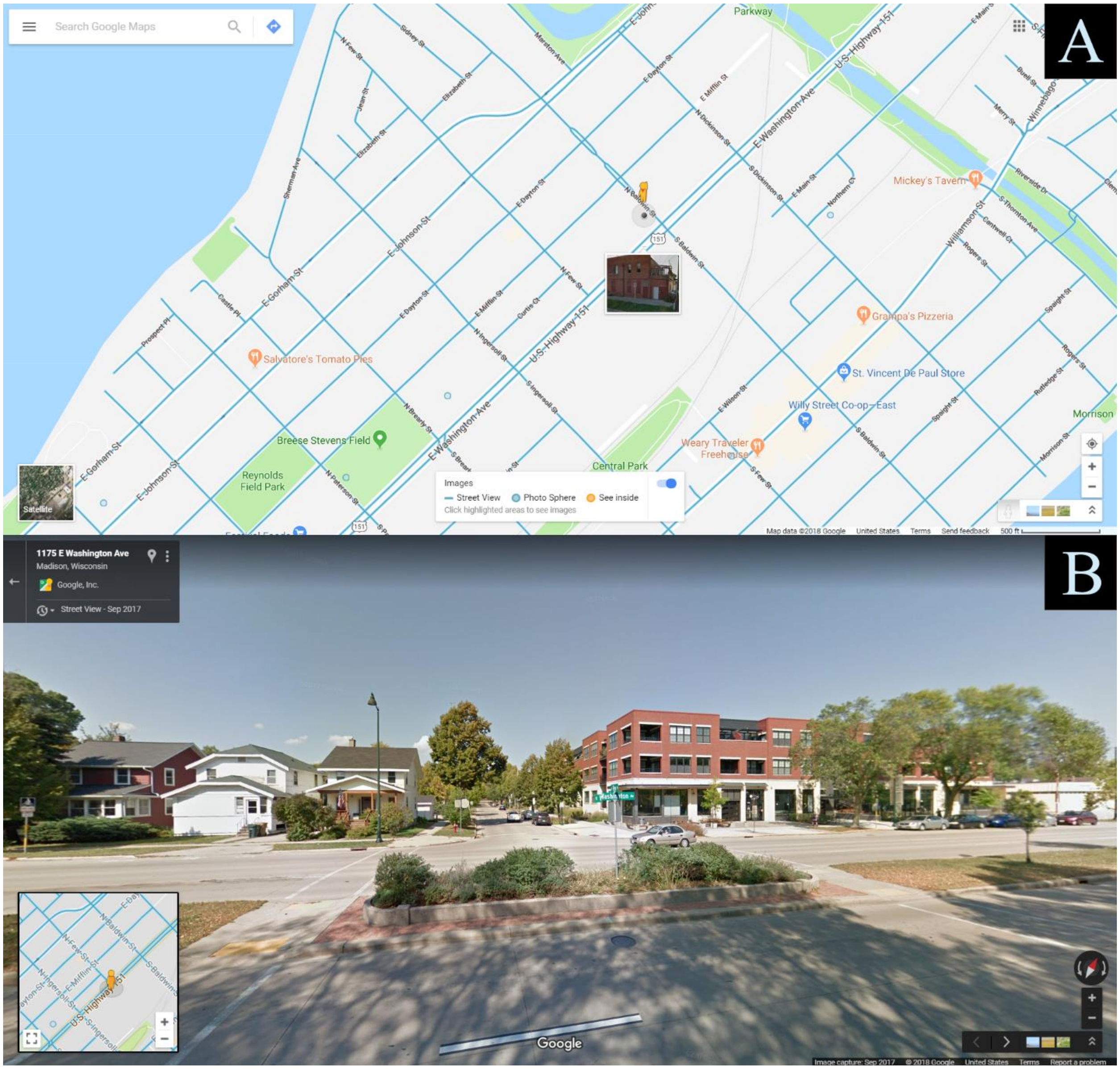



**Figure 2.4. Evoking new map information (i.e., *retrieve*) through Pegman in Google Maps is an example of secondary interaction in traditional interactive cartography. As you drop Pegman on the map (A) and 'move' through the streets, images of the street and surrounding landscape appear (B).**

opposed to a ***geocentric*** map design that is centered on the space the map represents (van Elzakker et al. 2008, Schmid et al. 2010). While mobile maps utilize location-based services and technology (e.g., GPS, gyroscope) in the mobile device to support secondary interaction, rather than relying on an avatar, this change in the map display nonetheless occurs without primary user input into the mapping interface. In this way, the user's body serves as the avatar for secondary interaction on traditional mobile maps. Thus, tenets of playful map design in video games have direct applicability to maps designed for work productivity, particularly for wayfinding on mobile devices (e.g., Meng 2005, Roth et al. 2018).

Interactivity is also important to the definition of game genres (Wolf 2002). When attempting to define boundaries for genres, game theorists seek to provide some structure for classifying games but often find difficulty in creating mutually exclusive categories or creating too many categories to show meaningful relationships (Egenfeldt-Nielsen et al. 2013). While genres can be defined by several variables (e.g., theme of the content, art style of the game), Egenfeldt-Nielsen et al. (2013) propose four basic genres based on a game's criteria for success. ***Action*** games require proficient motor skills and hand-eye coordination for the player to achieve goals. ***Adventure*** games are characterized by demanding deeper-thinking and patience as the player works through the narrative of the game. ***Strategy*** games lie somewhere between the former two genres, requiring the player to think and act quickly in some circumstances, while demanding attention to and careful prioritization of several details over time. Finally, ***process-oriented*** games often lack in-game criteria for success, leaving the goals to be made up by the player as they explore the virtual world and master the interface. Like other categorizations of games, these genres might overlap where criteria of multiple genres exist in a particular game. However, they could offer a useful foundation for identifying correlations between gameplay and the maps used to facilitate gameplay.

### 2.1.2 Representing Interactivity

Representation is a second pillar of cartographic design (MacEachren 1995), describing all the possible ways that cartographers can portray information in the map. Interaction is visually represented using ***graphical user interfaces*** (GUIs), which include the map and the associated digital tools such as radio buttons, checkboxes, and slider widgets that allow interaction with the map (Roth 2013b). GUIs utilize the visual variables to embed information into the features on the map and interface (Bertin 1983, MacEachren 1992). Video game maps employ both GUIs and the visual variables to communicate geographic and game information as well as provide affordances and feedback about available primary and secondary interactions.

There are multiple ***interface styles*** that represent interaction operators in different and inequivalent ways (Roth 2013b) (Table 2.2). These styles are chosen based on the desired interaction operators for the map and provide different affordances and feedback to the user. Some styles (Figure 2.5 A-E) offer ***direct*** manipulation of the map or associated GUIs (i.e., the use of pointing devices or gesturing to probe, drag, and adjust the map and associated graphics) while others (Figure 2.5 F-I) use ***indirect*** inputs (e.g., keying devices or voice recognition) to commit changes in the map. Interface styles primarily are discussed in terms of productivity (e.g., point mileage and workload; see Shneiderman & Plaisant 2010), requiring new design tenets for implementation in playful maps. For playful maps in video games, indirect cartographic interaction can be committed through the avatar (i.e., secondary interaction) which does not fall under any of these interface styles.

The specific ways that representations can be manipulated to convey information in both the interface and map are known as the visual variables (Bertin 1983, MacEachren 1992). The ***visual variables*** describe the dimensions of a visual scene that humans process pre-attentively (i.e., perceptually), and thus are considered the basic building blocks of representation much like the interaction primitives are the basic building blocks of interaction. Table 2.3 defines the visual variables considered and Figure 2.6 provides examples of how the visual variables apply to point symbols (MacEachren et al. 2012).

| Interface Style | Description |
|---|---|
| **direct manipulation** | |
| ***map features*** | direct manipulation of the map features themselves |
| ***entire map*** | direct manipulation of the map as a whole |
| ***map legend*** | direct manipulation of a map legend that doubles as an interface widget |
| ***linked isomorph*** | direct manipulation of information elements in a second isomorphic view for coordinated visualization |
| ***interface widget*** | direct manipulation of an interface widget |
| **indirect manipulation** | |
| ***menu selection*** | selection of one or more items from a presented list |
| ***form fill-in*** | keyed in characters indicate desired parameters for single interaction |
| ***command language*** | specify interaction with powerful, formal syntax of variables and functions |
| ***natural language*** | specify interactions using spoken word |
| ***Avatar*** | player-controlled avatar used to commit interactions |

**Table 2.2 Descriptions of the nine direct and indirect interface styles along with the addition of the avatar interface style present in video games.**

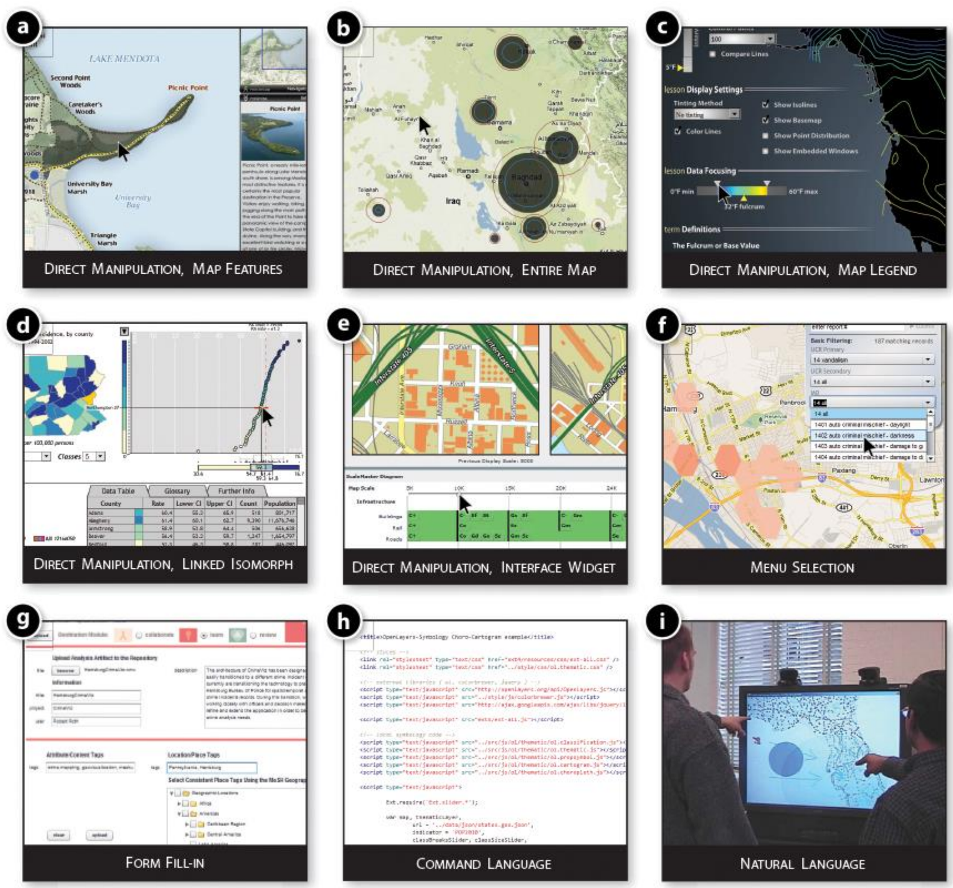



**Figure 2.5 Nine possible interface styles that allow for manipulation of the map and its features from Roth 2013b. The styles shown in (A) through (E) offer direct manipulation of the map and corresponding visuals through the interface. (F) through (I) depicts indirect manipulation of the map and visuals via keying devices or voice recognition.**

| Visual Variable | Description |
|---|---|
| ***location*** | the position of the map symbol relative to a coordinate frame. |
| ***size*** | the amount of space occupied by the map symbol |
| ***shape*** | the external form (i.e., the outline) of the symbol |
| ***orientation*** | the direction or rotation of the map symbol from 'normal' |
| ***color hue*** | the dominant wavelength of the map symbol on the visible portion of the electromagnetic spectrum (e.g., blue, green, red) |
| ***color value*** | the relative amount of energy emitted or reflected by the map symbol (i.e., the brightness of the symbol) |
| ***texture*** | the coarseness of the fill pattern within the map symbol |
| ***color saturation*** | the spectral peakedness of the map symbol across the visible spectrum |
| ***arrangement*** | the layout of graphic marks constituting a map symbol |
| ***crispness*** | the sharpness of the boundary of the map symbol |
| ***resolution*** | the spatial precision at which the map symbol is displayed |
| ***transparency*** | the amount of graphic blending between a map symbol and the background or underlying map symbols |

**Table 2.3 Definitions of Bertin's (1983), Morrison's (1974), and MacEachren's (1995) visual variables as defined by Roth (forthcoming)**

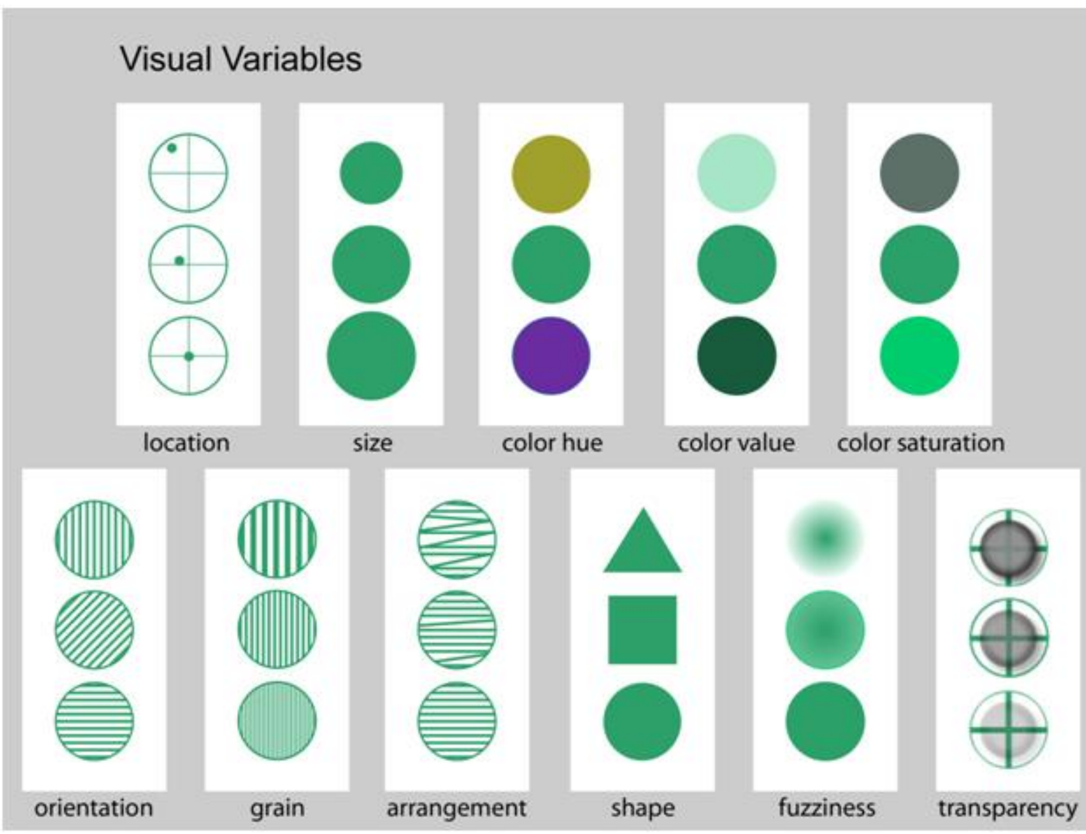



**Figure 2.6. Visual variables applied to point symbols (MacEachren et al. 2012). In a video game map, the visual variables may be applied differentially to distinguish among the YAH icon, vantage points, POIs, NPCs, other players in a multi-player game, and additional game artifacts or information. (Fuzziness has been since renamed as *crispness*).**

Representing primary interaction in a video game map is similar to traditional cartography. As introduced in Section 2.1.1, interactive cartographers use affordances paired with feedback to respectively highlight ways the user can interact with the map and communicate when an interaction has been committed, providing visual cues to educate the user about interactive functionality (Poplin 2015). One difference for video game maps is that there are not widely accepted design conventions for even the most common cartographic interaction primitives. In traditional interactive cartography, panning and zooming are almost always included through direct manipulation of the map itself (i.e., “grab-and-drag”) (Harrower and Sheesley 2005). For mobile maps, users “pinch” the map and spread their fingers to zoom and “tap-and-drag” to pan (Muehlenhaus 2013), neither of which provide visual affordances but are arguably becoming transparently usable due to the ubiquity of interactive content on touchscreen displays (Roth and Harrower 2008). Video game cartography, however, has not collectively adopted standards for implementing these operators using console-specific controllers, and thus must rely on explicit visual affordances for novel interactive elements. Further, video game maps also might require complex tutorials, provide step-by-step walkthroughs, or embed in-game tips early in the game to train the user on core interactive functionality (see Mead 2014 for a taxonomy of learning materials for interactive maps).

Secondary interaction is represented through the YAH icon, as seen in mobile cartography. Even if no interactive operator functionality is available, the YAH symbol representing the avatar on the map uses the visual variables to provide real-time game information to the player. For instance, *location* often shows the avatar’s position in the game world and *orientation* potentially can show which direction the avatar is facing (Fraser and

Wilmott 2016). Like mobile cartography, the symbol updates upon moving or changing direction (Peterson 2014), providing visual feedback as the user navigates the virtual world.

In some open-world game titles, secondary interaction also is encouraged through ***vantage points*** that reveal new information on the map when visited (Pearce 2014, Fraser and Wilmott 2016). Vantage point locations often are symbolized explicitly in the map and explained during the opening tutorials of the game. The player is encouraged to move the avatar to the vantage point, which may be infrastructure (e.g., a tower) or raised topography (e.g., a mountain). Once the vantage point is reached, the map reveals symbols associated with new quests or game information, sometimes revealing and providing access to new areas of the game space as well. Vantage points first were implemented by Ubisoft in the *Assassin's Creed* franchise (Figure 2.7) in 2007 and continue to appear in other games like Monolith Production's *Middle-Earth: Shadow of Mordor* (2014) and Nintendo's *The Legend of Zelda: Breath of the Wild* (2017) (Williams 2017).

Maps in video games also show ***POIs*** (points of interest) such as cities, quest destinations, and other locations relevant to gameplay. In many cases, these POIs do not appear on the map until the user has discovered the location, in which case text appears on the screen and states that the POI location has been added to the map (see Section 2.3.2 on Representing Incompleteness for additional discussion).

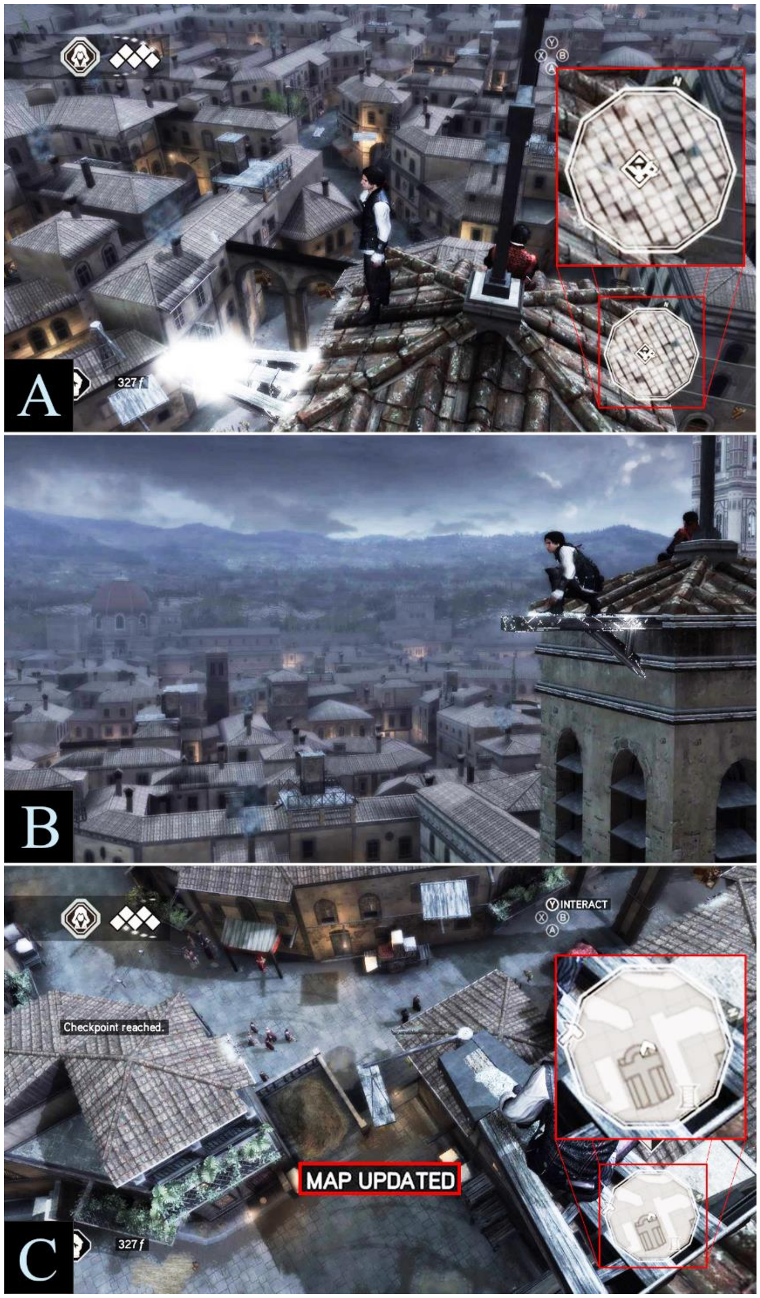



**Figure 2.7. Vantage points in *Assassin's Creed II* (Ubisoft 2009) require the player to climb a tall building. (A) The map is originally shrouded in a stylistic texture with a symbol showing the player where to go to reach the vantage point. Once the player "synchronizes" (i.e., scouts the immediate virtual world) from the explicit vantage point (B), the map changes to a detailed representation of the in-game cityscape and text appears telling the player that the map has been updated (C). (Elements outlined in red have been enlarged)**

## 2.2 Playful Maps Are Immersive

Immersiveness as recognized in cartography and related fields is different than the immersiveness of playful maps described here. Cartographic researchers typically look to technology like virtual and augmented reality or three-dimensional virtual environments when discussing cartographic immersion (e.g., Slocum et al. 2001, Cammack 2003, MacEachren et al. 2003). However, game researchers discuss a more imaginative immersion supported through the interactive experience, game narrative, game rules, and realism of the game environment and its map during play (Kaplan and Turkle 1986, Gee 2003, Taylor 2003, Dormann et al. 2006). While virtual and augmented reality are becoming more popular in the video game industry, video games of all platforms attempt to provide the latter type of immersion for the player. Many people play video games to escape normal life and immerse themselves in a new world and identity (Lazzaro 2004, Sweetser and Wyeth 2005). The map provided in the video game must also be immersive to serve this purpose of the game. This section explores how the map fosters playful immersion through interactivity and graphical representation.

### 2.2.1 Immersion Through Interactivity

Taylor (2003: pg 12) defines immersiveness as “[t]he degree to which the player feels integrated with the game space,” and describes two nested levels of immersion: diegetic immersion and situated immersion. ***Diegetic immersion*** refers to the degree to which the player feels immersed in the activity of playing the video game, while ***situated immersion*** describes when the player feels immersed in the game space and story. Diegetic immersion is equivalent across many forms of media such as watching a movie or reading a novel. Situated immersion, however, is embodied and requires assuming the perspective or point-of-view of the avatar or other character identities (Taylor 2003). Primary and secondary interaction in a video game map contribute to both kinds of immersion, although secondary interaction through an avatar is particularly important for situated immersion.

Diegetic immersion for primary and secondary interaction is the same: the player is immersed in the activity of controlling a cursor on the map or the avatar in the game in order to change the map. The player becomes absorbed in the interaction, focusing attention less on the real world around them and more on the actions taking place in the game environment and associated map. During map-based diegetic immersion, the activities of using the game map demand similar attention as if committed in the real world (Kaplan and Turkle 1986). The saliency of the map as recognized by Gekker (2016) contributes to diegetic immersion. For instance, diegetic immersion can be supported through a ***full-sized map*** that serves as a basic reference for the game environment. Here, the player typically evokes the map through a start menu button to examine the map and plan game strategy much like a reference map in the real world. While this action may not pause the game, the map demands the full attention of the player, preventing non-cartographic in-game interactions (e.g., moving the avatar through the virtual world). Diegetic immersion also can be supported through a persistent ***mini-map*** used like a heads-up locator map atop the game environment itself in a manner similar to augmented reality. Such mini-maps provide players with wayfinding information while navigating the virtual world much like how a mobile device is referenced while walking or driving in the real world. A game may include multiple map types, such as *The Legend of Zelda: Breath of the Wild* (Nintendo 2017) that offers a mini-map that is docked in the corner of the screen during gameplay as well as a full-sized map evoked through the start button (Figure 2.8). For both full-sized maps and mini-maps, diegetic immersion helps the user focus on the spatial components of the game.

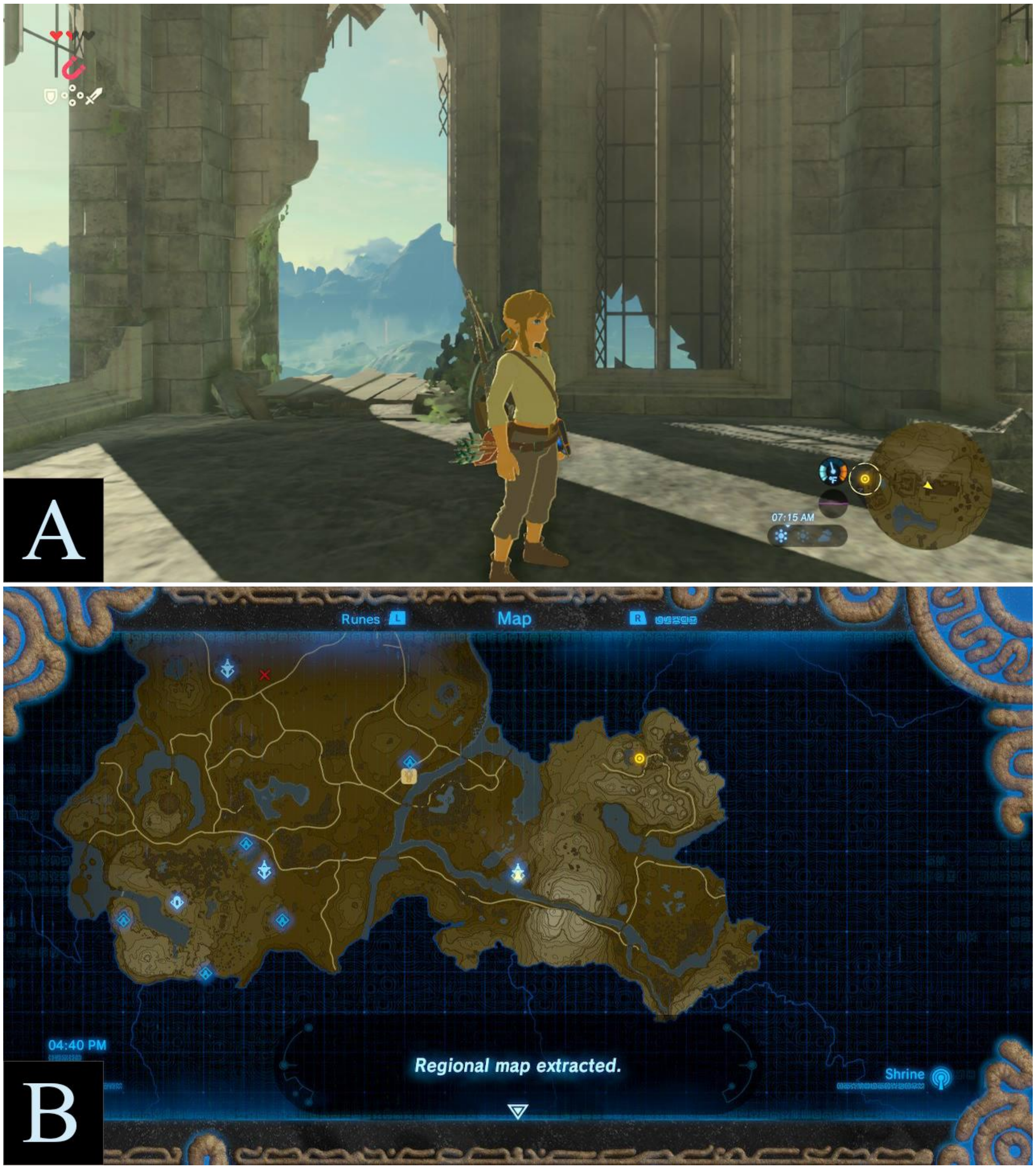



**Figure 2.8. (A) *The Legend of Zelda: Breath of the Wild* (Nintendo 2017) provides a persistent, egocentric mini-map in the corner that does not inhibit any other in-game actions. (B) A full-sized map also is provided that does not allow any other (i.e., non-cartographic) in-game action when evoked.**

Situated immersion can be achieved only after diegetic immersion occurs, as the player must be immersed in the act of the playing the game before being immersed in the virtual world and story (Taylor 2003). Situated immersion primarily is supported through secondary interactions driven by the avatar. To close the mental gap between the avatar and the player for situated immersion, such secondary interactions must be ***natural metaphors***, evoking an interaction between the avatar and map that is consistent with how a human and a map interact in the real world (Cartwright et al. 2001). In this way, players cognitively place themselves in the role of the avatar. For example, *The Legend of Zelda: Breath of the Wild* (Nintendo 2017) provides a cartographic interface identical to the one that Link, the player-controlled avatar, would see on the tablet device he carries and uses in the game (Figure 2.9a). When the player activates the full-sized map, the screen appears as though it is the exact screen the avatar would use to look at their map. Similarly, the player-controlled avatar in *Fallout 3* (Bethesda 2008) wears a ‘personal information processor’ device on their wrist, which contains information like health and inventory of the avatar as well as the map (Figure 2.9b). When the player pauses the game, the avatar looks down at the device, with the screen then filled with the full-sized map and its interface operators. While a start menu button is used to evoke the map, the full-sized map appears as naturally as using a joystick to control the movements of the avatar, further immersing the player into the role of the avatar. As the player makes changes to the interface using the menu selection interface style at the bottom of the display, the decorative 3D dials on the periphery of the device are moved as if the avatar is adjusting them, resulting in situated immersion (Gekker 2016).

Some video games include maps that do not pause the game and may not take up the entirety of the screen nor exist as a small persistent mini-map in the corner of the screen but are still evoked with certain controls. These ***active maps*** support situated immersion and require the player to divide their attention between active gameplay and map use, as some game actions (e.g., avatar movement) may be possible when the map is evoked. For instance, *Far Cry 2* (Ubisoft 2008) includes an active map that offers functionality and demands divided attention similar to how one might interact with a paper map when navigating in the real world (Figure 2.10ab). Situated immersion may also be supported by the blending of the map with the virtual

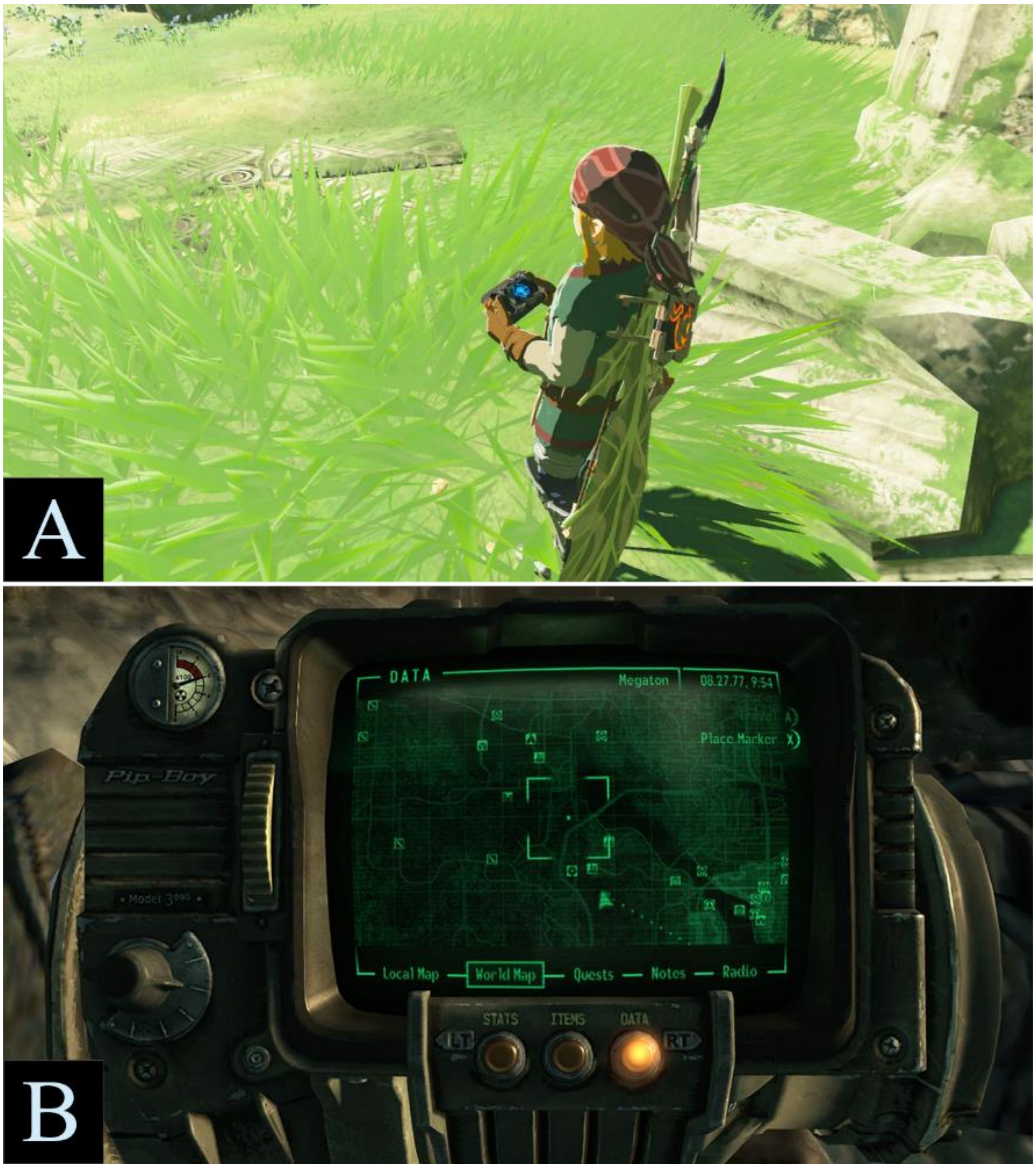



**Figure 2.9. Cartographic interactions that are natural metaphors support situated immersion in video games. (A) Link in *The Legend of Zelda: Breath of the Wild* (Nintendo 2017) holds a tablet-like device where he interacts with the map. When the start-menu map is called, the screen of the in-game tablet takes up the entirety of the screen, enforcing situated immersion. (B) In *Fallout 3* (Bethesda 2008), the "Pip-Boy" is a device that displays game information and is called when the player pauses the game. The device appears on the wrist of the player-controlled avatar, allowing for situated immersion when the player evokes the full-sized map and interacts with the interface.**

world in what is a ***superimposed map*** (Gekker 2016). In games with superimposed maps like *Sid Meier's Civilization V* (Firaxis Games 2010), the player controls one or more avatars that coexist with map features such as POI symbols and borders (Figure 2.10 c,d). Interactions with the entities and map features in the game occur in the same virtual interface. Both active and superimposed maps support situated immersion into the world and context of the game.

Maps are not always readily available to the player and must be acquired through gameplay. These ***map artifacts*** are retrieved or crafted by the avatar and may be any of the map types listed above (full-sized, mini, active, or superimposed). For instance, Figure 2.11 shows examples of map artifacts as the active map in *Minecraft* (Mojang 2009) and the full-screen map in *The Legend of Zelda: Wind Waker* (Nintendo 2003). Map artifacts support situated immersion as they are always acquired by secondary interaction and may even occupy a slot in the avatar's inventory.

### 2.2.2 Representing Immersiveness

Video game maps support situated immersion by incorporating an aesthetic style that matches the game setting and virtual world. ***Aesthetics*** broadly refer to concepts pertaining to beauty in any particular social context, while ***style***, more specifically, refers to the elements and characteristics that give a map (or any other form of media) a consistent and recognizable look and feel (Denil 2012, Knoppke-Wetzel 2014). Many maps, traditional and playful, develop a purposeful aesthetic style, often mimicking a certain time period or geography in order to immerse the users in a particular time, place, and emotional state. Cartographic researchers have systematically evaluated and compared related maps based on their aesthetic style, design, and

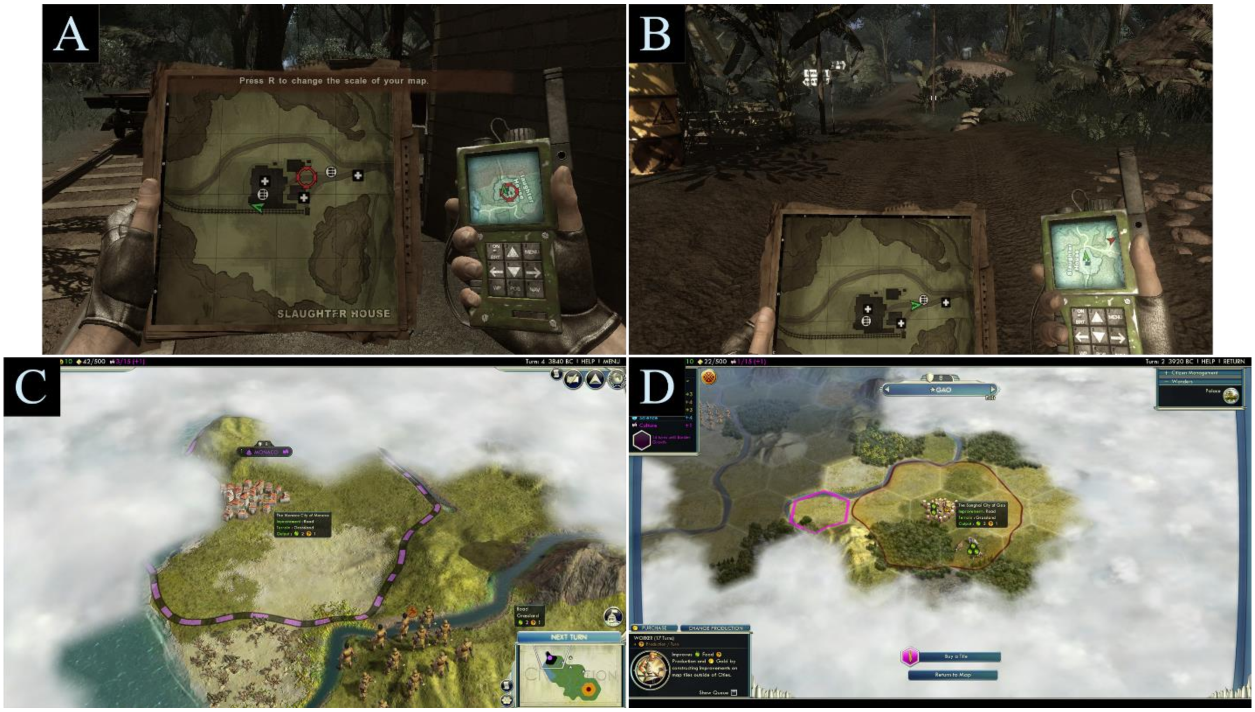



**Figure 2.10. Active and superimposed maps are both used to enforce situated immersion. (A) The player can evoke the active map in *Far Cry 2* (Ubisoft 2008) to take up a majority of the screen. (B) Some in-game actions, such as moving the avatar, are still possible during map use, and when committing the other possible actions, the map is lowered yet viewable. While movement is still possible during active map use, other actions like using a weapon are not and require the player to 'put away' the map. The superimposed map in *Sid Meier's Civilization V* (Firaxis Games 2010) allows for the player to interact with avatars or objects in the virtual world and map features simultaneously. Boundaries of map features (C) and the map grid (D) are visible during gameplay.**

composition (e.g., Muehlenhaus 2013, Knoppke-Wetzel 2014). Similarly, video games often employ maps of a particular aesthetic style to enhance the narrative setting of the game and motivate play (Jenkins 2004). This style often is congruent with the game environment and characters, matching virtual buildings, landscapes, challenges, and character roles and therefore reinforcing the player's situated immersion in the game.

For a map to immerse a player aesthetically, the style of the map must match what the player expects from the time and place of the game narrative. This mimicry is attained by manipulating the form of points, lines and polygons, the typography, the color palette, textural elements and other cartographic design choices related to the visual variables that are congruent

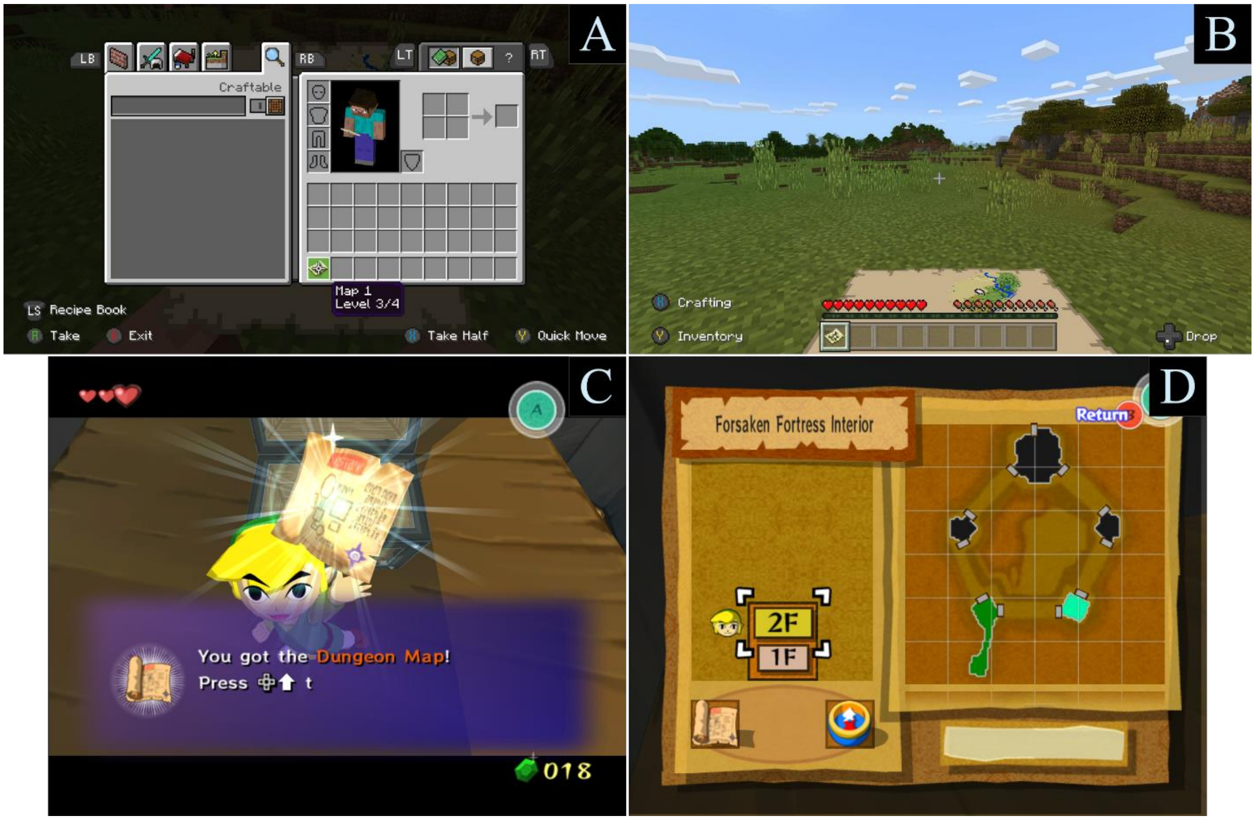



**Figure 2.11. Map artifacts are in-game maps that are acquired during gameplay. The map artifact in *Minecraft* (Mojang 2009) takes up a slot in the avatar's inventory (A) and behaves as an active map when in use (B). A single map artifact is provided at the beginning of the game but may be removed from the inventory. (C) In *The Legend of Zelda: Wind Waker* (Nintendo 2002) the map artifact for a dungeon is found in a chest but does not take up a slot in the avatar's inventory and cannot be lost. (D) When evoked, the map takes up the entirety of the screen as a full-sized map.**

with the desired style. For instance, Figure 2.12 compares a GPS-like mini-map that highlights driving routes in *Grand Theft Auto IV* (Rockstar Games 2008) to an antique full-sized map showing the world in *The Elder Scrolls IV: Oblivion* (Bethesda 2008). *Grand Theft Auto IV* takes place in a fictional modern-day metropolis, where GPS navigation and smartphones are prevalent in the game. The map is designed to mimic this modern, state-of-the-art style, using a bold orange *color hue* for route navigation that creates an apparent visual hierarchy from the high contrast with the dark monochromatic background and roads. The full-sized map from *The Elder Scrolls IV: Oblivion* uses a tan, paper-like texture to mimic antique paper maps that the player


**Figure 2.12. Maps in video games use form, typography, colors, and textures that match the player's expectation of the game setting to enforce situated immersion. (A) While the mini-map in *Grand Theft Auto: IV* (Rockstar Games, 2008) lacks typography and texture, it uses detailed and accurate linework (i.e., form) on a dark, monochromatic background. (B) The full-sized map in *The Elder Scrolls IV: Oblivion* (Bethesda 2008) (B) mimics an antique map through the use of a muted color palette, detailed and accurate form, and paper-like texture.**

would expect a medieval-era character to use, with detailed and accurate linework. With both the look of the map and the interactions provided similar to what the player imagines the character would experience, the identities of the player and game character become blended and situated immersion is achieved (Gee 2003).

## 2.3 Playful Maps Are Incomplete

Regardless of technology or context, maps are intended to communicate information to the reader (Muehlenhaus 2013). Traditional maps strive to be information-dense yet visually pleasing, attempting to balance the provision of enough data to the map user but not overcrowding the map as to compromise the communicative purpose of the map (Tufte 1983, Skupin 2000, Brewer 2015). Mobile mapping platforms like Google Maps provide a plethora of information, often showing POIs that may not be of interest to the user (Coulton et al. 2017). Playful maps in video games, however, intentionally provide an incomplete picture of the game world to the player.

While maps help the user in achieving game tasks, an incomplete map is another force working *against* the player (Fraser and Wilmott 2016). However, gradually completing the map is often an achievable and satisfying task, creating a ’pleasantly frustrating’ experience present in successful games (Gee 2003). Game designers leverage the player’s desire for completeness by providing an incomplete map as yet another challenge to be conquered by the player.

### 2.3.1 Completing the Map with Interactivity

In interactive cartography, the concept of exploration is associated with Shneiderman’s (1996) mantra for information visualization: “Overview, zoom/filter, retrieve details”. In such a case, the user commits primary interactions with a complete map, ‘exploring’ through a large volume of map information to find the details they need. While this mantra is applicable to primary interaction in complex, information-dense video game maps, many video game maps are initially void of information and require the user to play the game and move around in the virtual world, ‘exploring’ in a different sense than typical in interactive cartography to complete the map.

Game creators often push exploration as a main theme of their games; they want the player to move around in the virtual world, discovering locations, items, or events as they explore (Aarseth 2007, Lammes and Wilmott 2016). One way the designer achieves this is by providing an incomplete map at the onset of the game. A map that is incomplete fosters exploration, encouraging the user to complete the map via secondary interaction with the avatar (Lammes 2008). As introduced in Section 2.1.2, playful maps represent interactivity in the map through YAH symbols, vantage points, POIs, and NPC symbols. Discovering the player's location, additional vantage points, new POIs, and new NPCs are some of the more prevalent ways with which the user can complete the map through secondary interaction. Completing the map becomes a part of the game itself, with gameplay information, badges, achievements, or in-game artifacts often awarded for doing so. For instance, Team Cherry's *Hollow Knight* (2017) includes an achievement titled "Cartographer" for unlocking the map of each area in the game (although not designing the map's symbolization, typography, etc.), explicitly making the player a mapmaker during exploratory gameplay through incompleteness (Lammes 2008). Even without such achievements, a completed map becomes an award in itself for exploring the landscape, granting the player access to new spatial information needed for game strategy. Often after 'beating' the final quest or level of the game, players return to unexplored areas of the game space to complete all additional game tasks, reveling in a 'fully complete' video game and associated map (Lazzaro 2004, Sweetser and Wyeth 2005). The end goal of incorporating 'unlockable' geographic information, whether it be extent or features, is to allow the player to become a mapmaker and complete the map through play (Lammes 2008).

### 2.3.2 Representing Incompleteness

Representing incompleteness in playful maps relates to research on uncertainty visualization in cartography and related fields (e.g., MacEachren 1992, Leitner & Buttenfield 2000, Edwards & Nelson 2001, Viard et al. 2011, Kubicek & Sasinka 2011, Kinkeldey et al. 2014), with uncertainty including concepts like accuracy, precision, and trustworthiness. Incompleteness is an additional form of uncertainty in geographic information describing the presence or absence of information (Robinson 2018), and a map feature can be incomplete in its spatial position (most typical use in video game maps), its temporal existence, and its attribute information (MacEachren et al. 2005). MacEachren et al. (2012) recommend use of the visual variables crispness, location, and color value for representation of uncertainty in point features like YAH symbols, vantage points, POIs, and NPCs, and also recommend use of iconic, realistic representations of specific kinds of uncertainty over simple, abstract depictions.

A video game map can be incomplete in two ways relating to spatial information: incomplete by extent and incomplete by features. Video game maps that are ***incomplete by extent*** hide portions of the explorable virtual world. These maps often use ***fuzzy boundaries*** for representing polygonal incompleteness, separating discovered and unexplored territories through visual variables such as *color value* or *crispness* (Fraser and Wilmott 2016) (Figure 2.13). The unexplored regions, whether separated by fuzzy or discrete boundaries, are often darkened or completely obscured by 'fog of war' (coincidentally, MacEachren 1992 original described this extrinsic solution as "fog"), encouraging the player to explore these areas and master the space of the game (Lammes 2008, Coulton et al. 2017) (Figure 2.13). These darkened regions may be revealed in real-time as the player moves the avatar through the virtual world or unlocked when the avatar reaches a specific vantage point or interacts with a particular NPC (Lammes 2008, Fraser and Wilmott 2016).

When a map is ***incomplete by features***, symbols such as the user's location, vantage points, POIs, and NPCs are intentionally omitted from the map. In many cases, features are added to the map through secondary interaction with the avatar through ***symbol discovery***.


**Figure 2.13. (A) *The Legend of Zelda: Breath of the Wild* (Nintendo 2017) and (B) *The Elder Scrolls IV: Oblivion* (Bethesda 2006) both provide incomplete maps for the player to fill out. While (A) shows discrete boundaries and (B) uses fuzzy boundaries to distinguish between what has and has not been discovered, both maps suggest exploration is key to revealing more of the map.**

Sometimes, these features are revealed on the map before the player has discovered them to indicate which location the player needs to visit next, using different visual variables to distinguish between discovered and undiscovered features. For instance, in Bethesda's *The Elder Scrolls V: Skyrim* (2011), discovered and undiscovered POIs are represented differently on the map using the visual variable *color value* (Figure 2.14). The map is initially void of POIs until a POI is discovered during real-time exploration or the player-controlled avatar 'learns' of a particular POI associated with a quest (e.g., an ancient tomb is mentioned in a conversation with a townsfolk NPC), as opposed to vantage points that may reveal features or geography without the avatar actually visiting those locations. When the latter occurs, a black symbol with a white outline appears on the map, showing the user where they need to go. Once the player reaches the location, a message is displayed informing the user that the location has been discovered. When the player subsequently checks the map, the symbol has changed to white with a black outline. This distinction between discovered and undiscovered locations encourages the player to explore the world and find new locations.

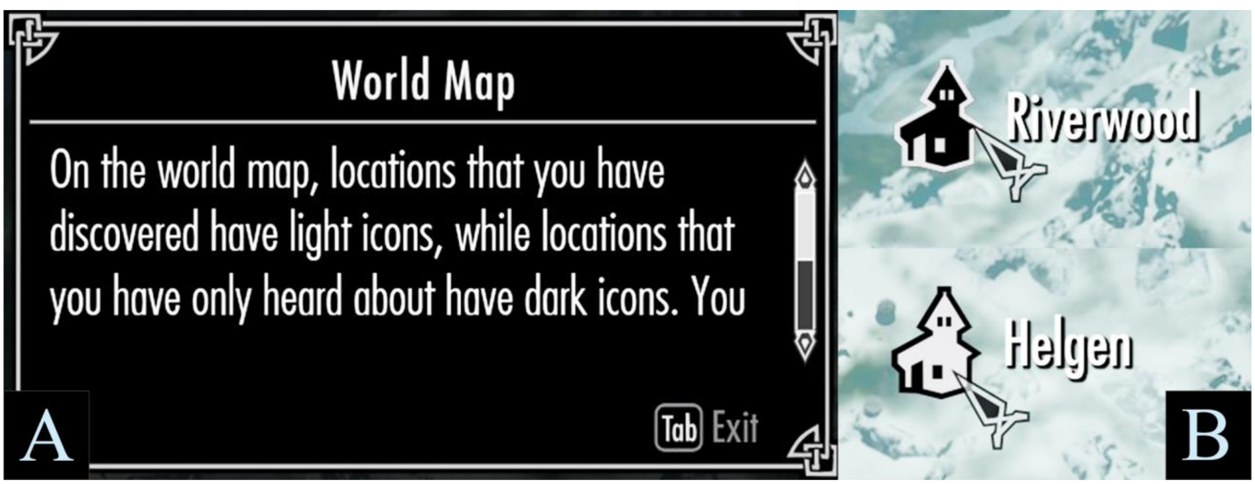



**Figure 2.14.** ***The Elder Scrolls V: Skyrim*** **displays a tip at the beginning of the game, teaching the user about how icons the player has heard of are** ***resymbolized*** **when the avatar visits their location (A). The town of Riverwood was mentioned by an NPC but has not yet been visited by the avatar, indicated by its "dark icon," while the town of Helgen has been visited and is symbolized by a "light icon" (B).**

Additionally, the map may depict features such as allies and enemies in the game space, but limit how much information is revealed about their locations. For instance, Bungie's *Halo 3* (2007) provides a radar-like mini-map for the player to see locations of teammates and opponents relative to themselves (Figure 2.15). While showing the planar proximity, the map does not reveal the vertical location of those players. This incorporates a challenge into gameplay that takes place in a game space with varying verticality. In a multi-level building, the player may see an enemy location appearing close to them but would not know if that player is located on the same floor as them. This incompleteness in the map, similar to a game that completely excludes a map, facilitates a challenging and exciting game experience for the player (Egenfeldt-Nielsen et al. 2013).


**Figure 2.15. In *Halo 3*'s (Bungie 2007) radar-like mini-map, allies are shown as yellow dots and enemies are shown as red dots. However, this map merely shows the horizontal proximity to these players and does not reveal whether they are above, below, or at the same elevation as the user.**

## 2.4 Playful Maps Are Inclusive

Play is a socially communicative activity that often involves collaborating with or competing against multiple people (Sutton-Smith 1971, Bateson 1972/2000). With many games (both tabletop and digital) requiring multiple players, social communication often is an essential element to gameplay (Szalavári et al. 1998). Maps in these games often foster collaboration, making map use an inclusive experience. Tabletop ***role-playing games*** (RPGs) like *Dungeons & Dragons* are games where a group of people, refereed by a game master, collaboratively construct a narrative through gameplay. Maps of the imaginary worlds in tabletop RPGs aid communication between players and situate gameplay within the narrative and space of the game (Röhl & Herbrik 2008).

Video games, being inherently audio-visual, do not need maps to help players imagine the game world. However, video game maps act as a collaborative tool for players to reference when working together in a video game. While many popular video game titles are ***single-player*** games, meaning that one person plays the game by themselves, several titles include ***multiplayer*** game modes. Maps in multiplayer video games provide information for players to discuss when playing together, sometimes allowing teammates to view and interact with the same map.

### 2.4.1 Inclusive Interactivity

Traditional cartography has investigated inclusive map design as part of the research thrust of ***geocollaboration***, or the use of maps or spatial information for coordinated work productivity in various contexts (e.g., MacEachren et al. 2003, MacEachren and Brewer 2004). Multiple users interact with geospatial data through a shared visual interface within a ***collaborative virtual environment*** (CVE) (MacEachren and Brewer 2004). Researchers recognize a CVE's potential to foster discussion and flow of information as well as collective problem solving and decision making.

Collaboration can occur in different contexts, with groups contributing or communicating across space and time (MacEachren and Brewer 2004). Groups can work in the same location or different locations and at the same time or different times, resulting in four spatiotemporal geocollaborative contexts that also apply to playful situations (Figure 2.16). Group dynamic and decision-making varies across these contexts and requires separate considerations for both cartographic interaction and representation design. For instance, greater affordances and feedback are needed for different-place and different-time collaboration than same-place and same-time collaboration to keep the team apprised of the action of others in lieu of direct conversation in real place and time.

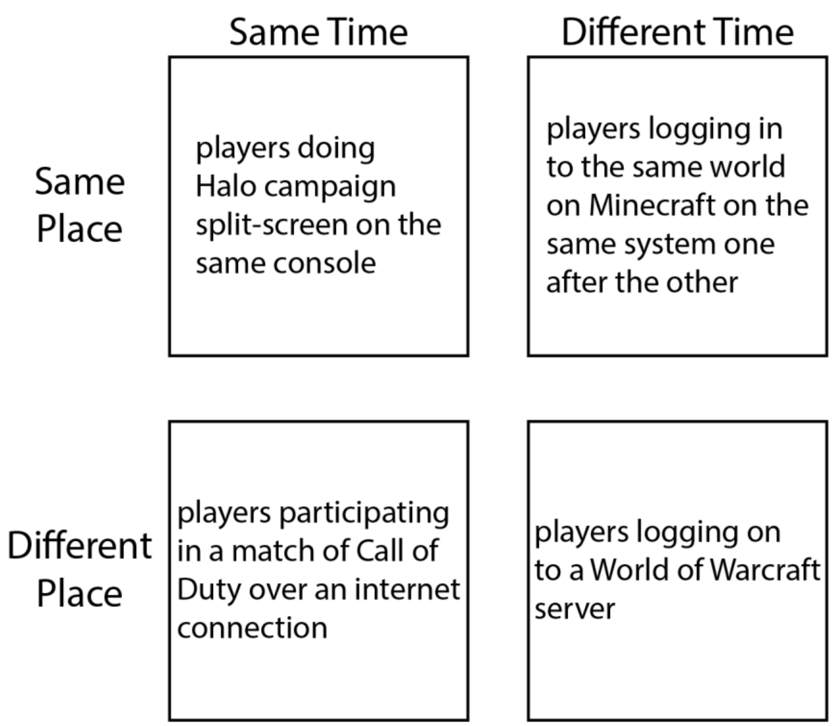



**Figure 2.16. Multiplayer video game experiences that apply to each of the four space-time geocollaborative contexts.**

Multiplayer video games maps also function within these spatiotemporal geocollaborative contexts, although they can foster both collaboration among allies and competition among enemies (Zagal 2006). For instance, *Call of Duty: WWII* (Sledgehammer Games 2017) is a first-person shooter that can create both competitive and collaborative relationships among multi-player avatars. Players compete and collaborate through secondary interactions with the mini-map in both the same place or in different places using network connections at the same time. Figure 2.17 shows two examples of the *Call of Duty* mini-map that can be altered through secondary interaction: one that has been augmented by the player or the player's teammate to show enemy locations through an in-game reward and one that has been sabotaged by an opposing player. These secondary interactions resulting in collaboration or competition result in inclusive gameplay, with in-game interactions among avatars changing the map itself.

Some video game maps also foster inclusiveness through primary interaction. Epic Games' *Fortnite: Battle Royale* (2017) provides a map to the player that is shared among all players on the team. The map serves as a conduit of communication, encouraging players to discuss where they wish to go and how they want to get there. As the game only offers multiplayer gameplay through different-place, same-time internet connectivity, voice chat is the main way users communicate about the map and game space. However, players can also *annotate* the map with unique markers (Figure 2.18).

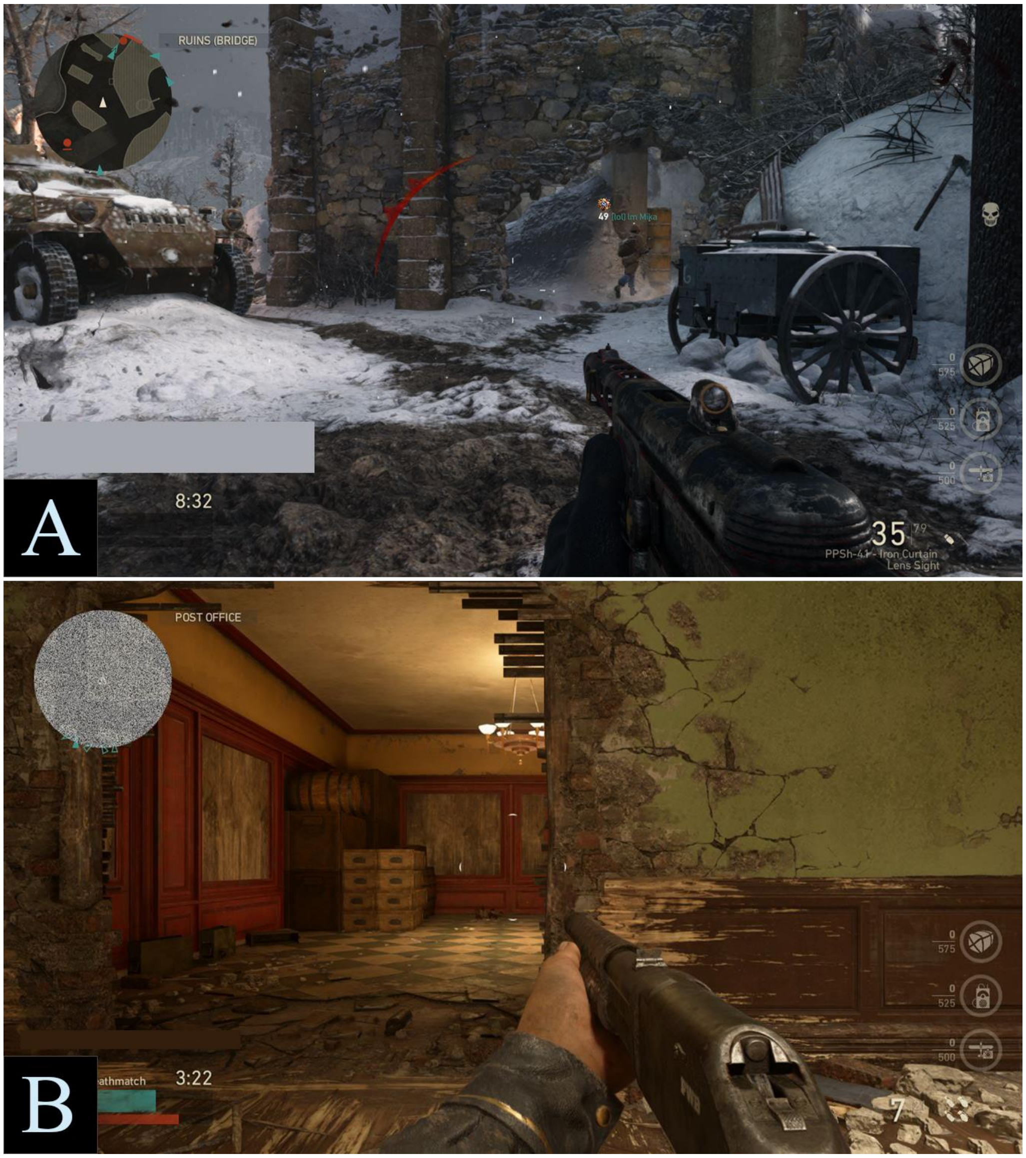



**Figure 2.17.** ***Call of Duty: WII*** **(Sledgehammer Games 2017) places a mini-map in the upper left-hand corner of the screen. (A) This map can be augmented by the user or other allies to show enemy locations or (B) it can also be sabotaged by enemy players to hide all information behind a static-like *overlay*.**

### 2.4.2 Representing Inclusiveness

Visual variables are used in inclusive video game maps to communicate information about the user and other players. The marker annotations included in Figure 2.18 use *color hue* to communicate which teammate placed the marker. *Halo 3* (Bungie 2007) provides a radar-like mini-map centered around the player icon. While the icon *shape* may change based on certain

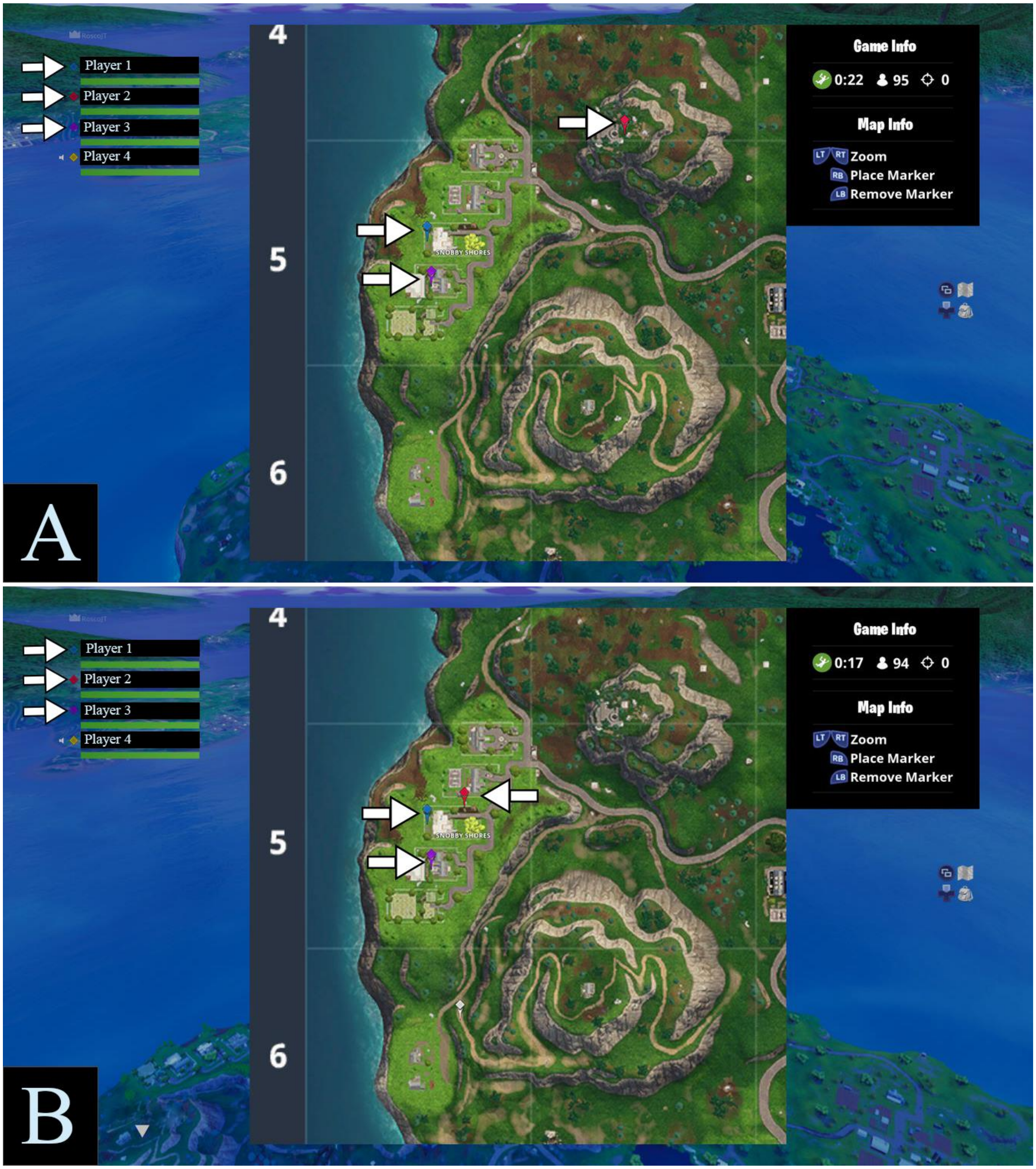



**Figure 2.18. In *Fortnite: Battle Royale* (Epic Games 2017), each player on a team can *annotate* the map, dropping markers to reference certain location during gameplay. In (A), each player on the team placed a unique marker (indicated by white arrows on the map) distinguished by a *color hue* randomly assigned to each player (indicated by white arrows in the upper left of the image). Players use these annotations to communicate where they would like to go. In (B), player 2 moved their red marker closer to the other markers placed by players 1 and 3.**

secondary interactions, the *color hue* remains the same. This color is also used to represent every allied player on the map, while another represents enemy players.

While this representation of nominal data is useful in recognizing player locations, some maps also represent more detailed player information on an ordinal or numerical scale. As mentioned in Section 2.3.2, *Halo 3* offers an incomplete picture of the game space by excluding verticality when representing other player locations. Subsequent *Halo* franchise games adopted symbolization to communicate this information to players, creating a different game experience. In *Halo: Reach* (Bungie 2010), the next game in the series, the mini-map provides information on the verticality of nearby players compared to the user. Players located above the user are symbolized with an upward pointed triangle, a different *shape* than players on the same level as the user, while players located below the user are symbolized by increased *transparency* (Figure 2.19). This symbolization evolved further in *Halo 4* (343 Industries 2012), with a simple upward or downward *oriented* chevron representing higher or lower players respectively. These examples of representation display how video games uniquely handle the inclusiveness of playful maps.

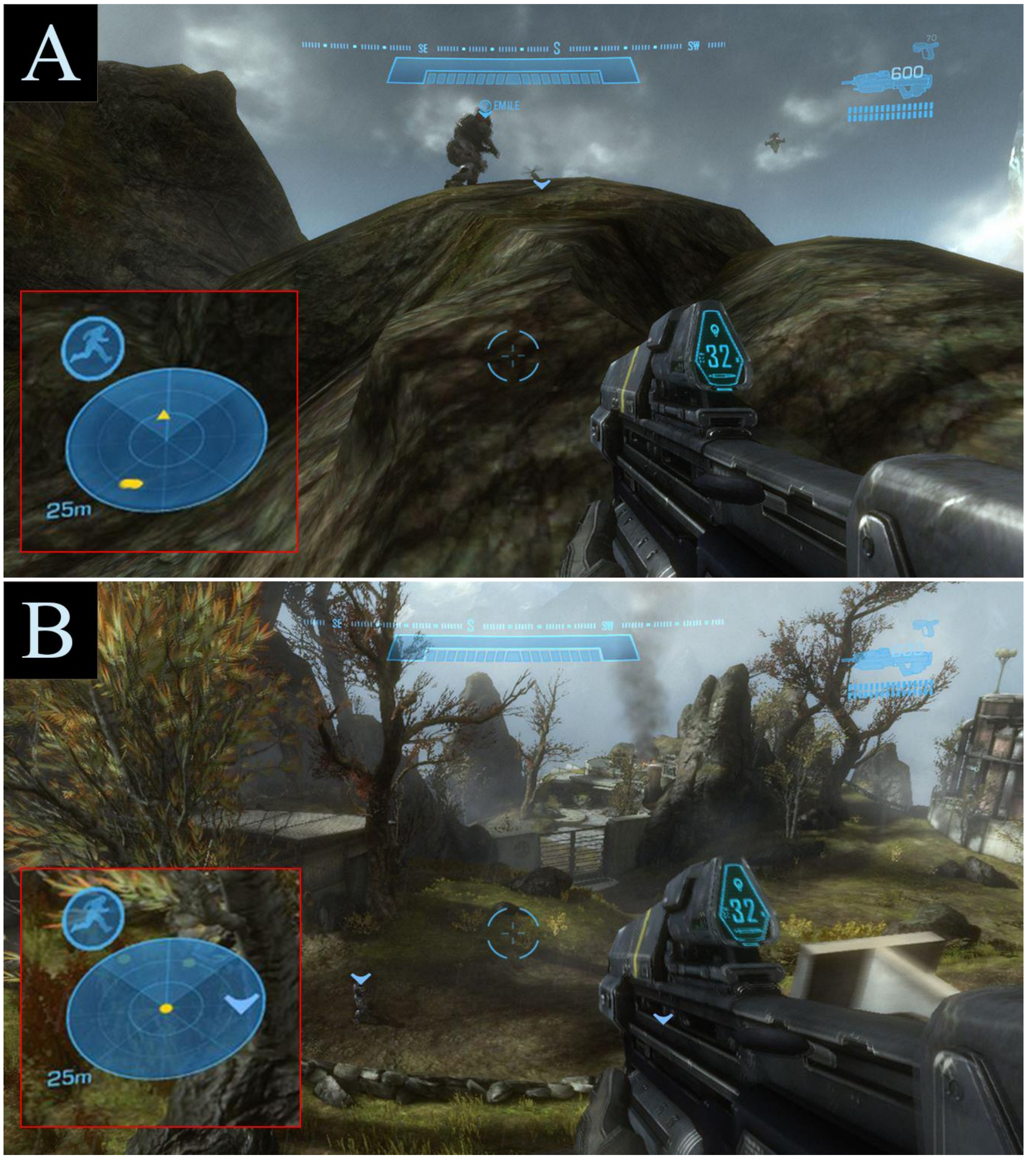



**Figure 2.19. The inclusive nature of multiplayer games requires their maps to show other players' positions. The map in *Halo: Reach* (Bungie 2010) symbolizes ally locations differently based on whether the other player is (A) above (symbolized with a triangle) or (B) below you (symbolized with transparency). (Maps have been enlarged to show detail)**

# Chapter 3: Methods

I used ***quantitative content analysis*** (QCA) to evaluate 71 playful maps from 50 popular video games released from 2012-2016. QCA uses researcher-defined codes to quantify otherwise repeating themes or traits within a coherent corpus of secondary sources, such as visual media and maps (Suchan and Brewer 2000, Muehlenhaus 2011). In the following sections, I describe the process for selecting my sample, the procedure for coding the sample, and the descriptive and visual analysis applied to the resulting codes.

## 3.1 Video Game Map Sample

The sample of 50 video games was drawn from Metacritic.com (2017), a website that compiles critical reviews for various media, allowing for the systematic choice of games. I selected video games from a span of five-year span ending in 2016, the most recent complete year in which games rankings were released on Metacritic at the onset of this research. A total of 4,172 games were ranked on Metacritic across the five-year span, serving as the baseline population for sampling.

I defined criteria to scope the sample of video games to a feasible size. First, the video game had to include a map for the player to use during gameplay. Second, I only considered video games available on Nintendo Gamecube, Nintendo 3DS, Microsoft Xbox 360, Microsoft Xbox One, Nintendo WiiU, and PC systems due to cost constraints of obtaining additional consoles. The majority of these games, however, were also available on platforms that were not included. Also related to cost, the video games must be available for purchase on digital marketplaces (e.g., G2A marketplace, Steam store, Xbox marketplace, Nintendo eShop) and used game stores (e.g., GameStop); where possible, I borrowed video games from the collections of personal friends and used games from my own collection. Finally, redundancies across systems and re-releases were omitted to avoid biasing the sample towards a specific design. After applying these constraints, I then selected the top-ten ranked games from each year, resulting in 50 unique video games under consideration.

Multiple maps within a single game were coded separately, as interaction and representation may differ with each map. In total, 71 video game maps were coded. Each sampled game map was given a unique ID in the analysis based on the title of the game, a number to distinguish the map from other maps in the same game, and the year it was released. Appendix A provides a complete list of video games included in the study.

## 3.2 Procedure

I applied 153 codes to the sample following recommendations in QCA (Appendix B). The codes were divided into four categories based on the playful game tropes introduced in Chapter 1: interactive, immersive, incomplete, and inclusive (Research Question #1). Each of these categories was further divided into the cartographic tenets of interaction and representation (Research Question #2). Each unique code included within these headings then was intended to capture congruencies and inconsistencies between traditional and playful map designs.

Under the interactivity of playful maps, Roth's (2013a) taxonomy of interaction operator primitives were examined according to primary and secondary interaction. Interaction representation was evaluated according to interface style and the cartographic features that are unique to video game maps (e.g., YAH symbol, vantage points, POIs, and NPCs). The presence or absence of help materials also was noted.

Interactive immersiveness of playful maps was coded by the type of map provided to the player (e.g., full-sized map, mini-map, active map, superimposed map) as first outlined by Gekker (2016) and augmented for this study. Additionally, games were coded based on whether the map was acquired as a map artifact, recording the type of map for cross-tabulation. Situated immersion in the map was coded by whether the interactions provided were a natural metaphor for how the avatar would interact with the map, as well as if the in-game map's style (representation) was congruent to what the user would expect in the virtual world and narrative context of the game. The representation of form, typography, color, and texture used in the maps also were coded based on how they reinforced situated immersion.

Similar to the interactivity of playful maps, the incompleteness of the playful maps was examined by Roth's (2013a) interaction operator primitives, recording which types of interactions could be used to complete the map. The operators were cross-tabulated with the levels (e.g., primary or secondary) of interaction. Representing incompleteness was divided into incompleteness by feature and extent. Incompleteness by feature leveraged the unique cartographic features of video game maps and whether the symbolization of those features could change (i.e., become complete). Codes for incompleteness by extent examined the presence of fuzzy boundaries and the visual variables used to represent them.

The inclusiveness of playful maps was coded according to the game itself and whether it was a single- or multiplayer game. Multiplayer games were further coded on the space/time contexts for geocollaboration and whether primary and secondary collaborative interactions were permitted. The representation of inclusiveness in multiplayer games assessed the visual variables used to represent other players and whether this representation can change through primary and/or secondary interactions of any players.

## 3.3 Analysis

Before these codes were finalized, 22 video game maps were coded based only on cartographic interaction design and representation design. After this preliminary analysis, codes were revised and situated within the four characteristics of playful maps. The revised codes described above used a binary schema (e.g., 0 or 1), identifying the presence or absence of certain features. Codes were developed to be as extensive as possible, attempting to cover multiple aspects of cartographic interaction and representation design. A subset of codes was recorded as strings for cross-referencing (Muehlenhaus 2011). A final, catch-all category of notes was maintained for additional observations when coding.

I conducted descriptive statistics of the codes to inform interpretation, determining averages and frequencies of codes for all sample video game maps (Rose 2001, Muehlenhaus 2011). These statistics were used to determine the prevalence of the coded characteristics and to compare map qualities across all video games, allowing for identifications of potentially over- or underused cartographic techniques as well as overall trends and patterns in video game cartography. These descriptive statistics also were useful in determining which of the codes developed yielded no meaningful results. Codes were then cross-tabulated with other relevant codes to highlight potentially meaningful correlations in playful map design.

# Chapter 4: Results

## 4.1 How Are Playful Maps Interactive?

The first category of codes examined the *interactive* characteristic of video game maps supporting play. I included two sets of codes regarding interaction levels: primary versus secondary levels of cartographic interaction and the operator primitives implemented at each level. I also included three sets of codes to capture how interactive elements were represented visually: interface styles employed for each operator primitive, visual affordances for UI features unique to video game cartography, and a binary code if help instructions or other learning materials were provided to inform use of the video game map. These categories and frequencies of each are listed in Table 4.1.

**Table 4.1 Descriptions of the codes used to evaluate interactivity in the analysis. The count refers to the number of maps that included that particular code with the percentage compared against the total number of maps in the sample (n=71).**

| Category | Code | Definition | | |
|---|---|---|---|---|
| Levels of Interaction | | | Count | % |
| operators | pan | change the geographic center of the map | 62 | 87% |
| | zoom | change the scale of the map | 35 | 49% |
| | annotate | add graphic markings and/or textual notes to map | 19 | 27% |
| | resymbolize | change design parameters of map features | 61 | 86% |
| | overlay | adjust (i.e., toggle visibility) of map features | 31 | 44% |
| | filter | identify map features meeting certain criteria | 6 | 8% |
| | retrieve | request specific details about map features | 42 | 59% |
| | save | store the geographic information of map | 52 | 73% |
| | edit | manipulate geographic information underyling the map | 8 | 11% |
| | import | load geographic information or previously generated map | 0 | 0% |
| | export | extract geographic information or generated map | 0 | 0% |
| | calculate | derive new information about map features of interest | 0 | 0% |
| | search | identify a particular location or map feature of interest | 0 | 0% |
| | reexpress | change the visual cartographic isomorph | 0 | 0% |
| | arrange | manipulate the layout of views | 0 | 0% |
| | sequence | generate an ordered set of maps | 0 | 0% |
| | rotate | change the orientation of the map | 22 | 31% |
| | reproject | change the map projection | 1 | 1% |

| | | | | |
|---|---|---|---|---|
| levels | primary | interaction committed through the cartographic interface and traditional controls in the virtual environment | 63 | 89% |
| | secondary | interaction committed through gameplay and controlling entities within the virtual world | 68 | 96% |
| Representing Interaction | | | | |
| interface styles | direct map feature | pointing device used to manipulate features in map | 35 | 54% |
| | direct entire map | pointing device used to manipulate the map as a whole | 38 | 49% |
| | direct map legend | pointing device used to manipulate the legend as an interface widget | 4 | 17% |
| | direct linked isomorph | pointing device used to manipulate map through a coordinated visualization (such as another map) | 6 | 6% |
| | menu selection | select one or several items from presented list | 51 | 8% |
| | avatar | avatar used to commit interactions with map features (i.e., secondary interaction) | 68 | 96% |
| unique UI | you-are-here symbol | symbol depicting the avatar within the virtual world | 69 | 97% |
| | vantage points | locations in the virtual world where the user must reach to add more geographic information to the map | 11 | 15% |
| | point of interest (POI) | locations in the virtual world that hold significance to gameplay (e.g., cities, fortresses, dungeons) | 59 | 83% |
| | non-player character (NPC) | entities within the game whose actions are pre-programmed in and controlled by the game (e.g., monsters, townsfolk) | 35 | 49% |
| help | learning materials | any tips provided to the player to instruct on functionality of the map and how to use it (provided as in-game dialogue or as a UI element) | 24 | 34% |

### 4.1.1 Levels of Interactivity

Of the seventy-one (n=71) maps included in the analysis, sixty-three (63/71, 89%) supported primary interaction and sixty-eight (68/71, 96%) supported secondary interaction. The pervasiveness of map interaction—both primary and secondary—in contemporary video games is a finding in itself, confirming interactivity as a fundamental design trope for playful maps. However, design strategies for implementing primary versus secondary interaction differed by operator. Primary interaction frequently was supported through *save* (50/63, 79%), *pan* (35/63, 56%), *zoom* (35/63, 56%), and *retrieve* (34/63, 54%), with each operator implemented in a majority of the maps supporting primary interaction. In contrast, secondary interaction was supported through *resymbolize* (59/68 87%), *pan* (51/68, 75%), and *overlay* (28/68, 41%), suggesting a narrower set of natural, intuitive, and useful ways for the avatar to manipulate the video game map.  Figure 4.1 visualizes the prevalence of all operators according to primary and secondary interaction.

*Save* was the most common primary interaction, implemented in fifty (50/63, 79%) of the video game maps. While *save* often is considered an enabling operator in maps designed for work productivity (Roth 2013a), the frequency of *save* in video game maps suggests that it may be more fundamental to a playful experience. Use of *save* through the video game map typically was associated with and committed by saving the overall current state of the game, allowing the player to pause and return to the game in a future gameplay session. Arguably, the ability to *save* reduces stress and enables more complex gameplay, perhaps at the cost of breaking both diegetic and situated immersion in a session of gameplay due to the interruption of in-game actions.

Roughly half of the maps supported *pan* (35/63, 56%) and *zoom* (35/63, 56%) through primary interaction, operators sometimes treated together as ***map browsing*** (Harrower & Sheesley 2005). While map browsing was implemented by primary interaction in a majority of video game maps, its frequency was surprisingly low given the conventional use of *pan* and *zoom* in web maps supporting work productivity. Variation in *pan* and *zoom* through primary interaction was explained by the video game map type (see Section 4.2.1 for additional discussion on map type related to immersiveness). Primary *panning* was implemented in 77% (24/31) of full-sized maps, 12% (4/33) of mini-maps, 100% (6/6) of superimposed maps, and 100% (1/1) of active maps. Primary *zooming* was provided in 68% (21/31) of full-sized maps, 21% (7/33) of mini-maps, 100% (6/6) of superimposed maps, and 100% (1/1) of active maps. Thus, primary *panning* and *zooming*, while seemingly ubiquitous in web maps (Woodruff 2010), are far less common in playful mini-maps. This finding has important implications for mobile

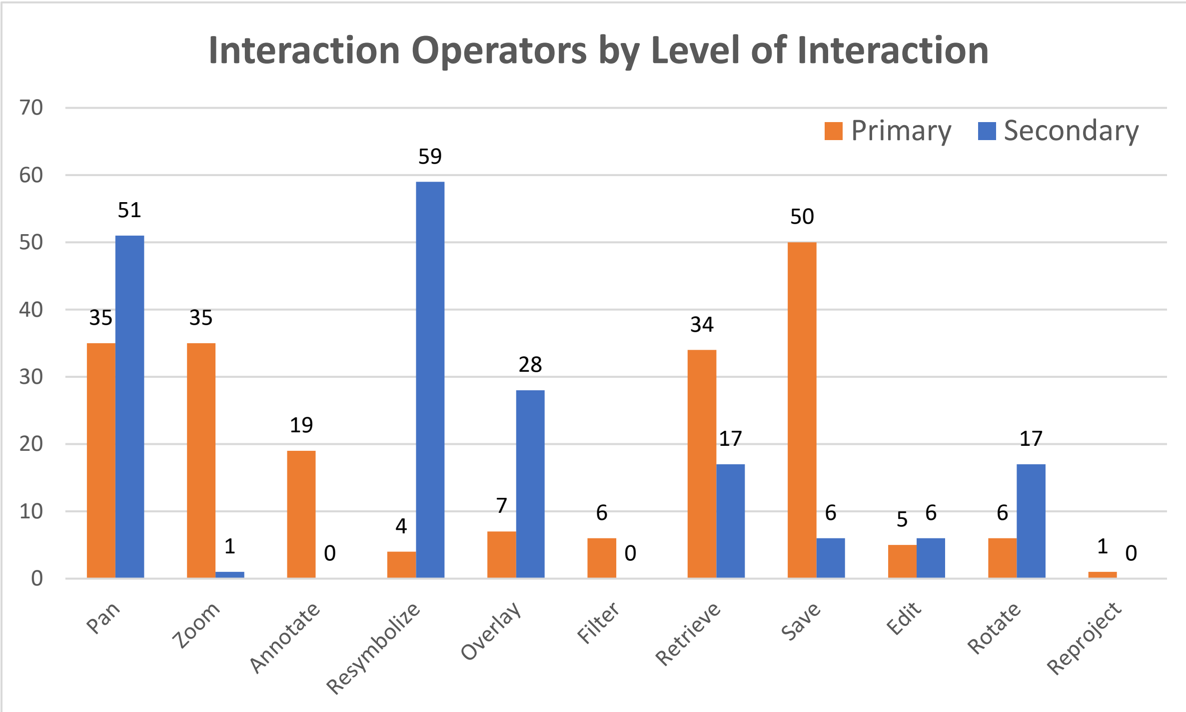



**Figure 4.1 Frequency of each operator categorized by level of interaction. Some operators were far more prevalent with a particular level of interaction, such as *resymbolize* as secondary interaction or *save* and *zoom* as primary interactions.**

map design, as a mobile map often acts like a mini-map reference while navigating in a real-world environment. Accordingly, it is possible that *pan* and *zoom* should be constrained as a primary interaction on mobile maps when wayfinding on foot or in a car, with map browsing instead implemented through secondary interaction (i.e., through changes to the user's location, rather than an avatar).

*Retrieve* was found in thirty-four (34/63, 54%) of the maps supporting primary interaction. *Retrieve* is a common operator paired with *pan* and *zoom* in web maps to let the user acquire more detailed information not displayed on the map, making the map the front-end interface to a large database of potentially relevant information (Tolochko 2016). I expected to find more examples of primary *retrieve*, considering the geographies of the games' virtual worlds are often fictional and unfamiliar to the player. However, the unexpectedly low frequency suggests an emphasis of video game maps as a quick visual reference for wayfinding, rather than an interface for retrieving complex game information. However, I found examples of both within the sample. For instance, *retrieve* in the full-sized map of *Child of Light* (Ubisoft 2014) reveals simple labels for POIs (Figure 4.2), while retrieving in the superimposed map of *Sid Meier's Civilization VI* (Firaxis Games 2016) shows complex details about the examined object (Figure 4.2).


**Figure 4.2 Information *retrieved* in *Child of Light* (Ubisoft 2014) (A) and *Sid Meier's Civilization VI* (Firaxis Games 2016) (B) varies in the amount of detail provided. *Retrieve* in *Child of Light* provides simple labels for POIs, while *Sid Meier's Civilization VI* provides terrain, political power, economy, population, and other information.**

The operators *annotate* (19/63, 30%), *overlay* (7/63, 11%), *filter* (6/63, 10%), *rotate* (6/63, 10%), *edit* (5/63, 8%), *resymbolize* (4/63, 6%), and *reproject* (1/63, 2%) were implemented using primary interaction in a subset of maps, but were not prominent across the sample. However, this small subset of maps did provide interesting insight into the use of *edit* versus other operators for future video game map design (and map design generally). *Edit* refers to the alteration or manipulation of geographic information in the map (Roth 2013a). In a video game, applying an *edit* to the map changes both the map and the associated virtual world, compared to *overlay* or *resymbolize*, which change the map but not the virtual world. Further, of the five maps that permitted primary *edit*, four of these maps were superimposed maps, where the virtual world and the map coexist in the same interface. Figure 4.3 shows how *edit* is provided through primary interaction in the superimposed map of *Sid Meier's Civilization VI* (Firaxis Games 2016). Of course, while editing in a traditional interactive map does not change the real world represented in the map, playful *edit* interfaces might translate to interactive maps supporting planning and geodesign, where the purpose of interactive editing is to propose alternative futures (Goodchild 2010).

I did not find examples of *import, export, calculate, search, reexpress, arrange,* or *sequence* operators using primary interaction in the sampled maps.

Secondary interaction was more prevalent than primary interaction in the video game map sample, with sixty-eight (68/71, 96%) of all maps allowing for some kind of secondary interaction. *Pan* was the most popular secondary interaction, with fifty-one (51/68, 72%) maps allowing the player to change the geographic center of the map by moving the avatar. I expected the frequent inclusion of secondary *pan,* as mini-maps often are egocentric and show geographic information immediately surrounding the player as they move through the virtual world in real-time. While only twenty-six of the maps permitting secondary *pan* were mini-maps (26/68, 79%), this represented 79% of all mini-maps present in the sample (26/33). Twenty-three (23/68, 45%) full-sized maps also permitted *pan* via secondary interaction, re-centering the map on the avatar's location when evoked. For instance, the full-sized map in *Middle-Earth: Shadow of Mordor* (Monolith Production 2014) centers on the avatar's location every time it is opened (Figure 4.4). This is particularly useful when traveling long virtual distances between map-use sessions, preventing the user from having to commit multiple primary interaction operators to achieve their goal (e.g., *pan* to their current location from the previously viewed location). In this way, inclusion of secondary interactions via the avatar can serve as accelerators that replace long sequences of primary interactions with the map (Shneiderman & Plaisant 2010), reducing workload for both traditional and playful maps.


**Figure 4.3 *Editing* in a video game map means changing the virtual world that the map represents, as seen in building a city in *Sid Meier's Civilization VI* (Firaxis Games 2016). The player can move their settlers to an open tile on the superimposed map (A) which is represented in the full-sized map (B). Once the settlers build a city and change the virtual world (C), a new symbol is added to the full-sized map (D). This differs from *overlay* or *resymbolize* as it is not only a change to the map, but a change to the virtual world.**

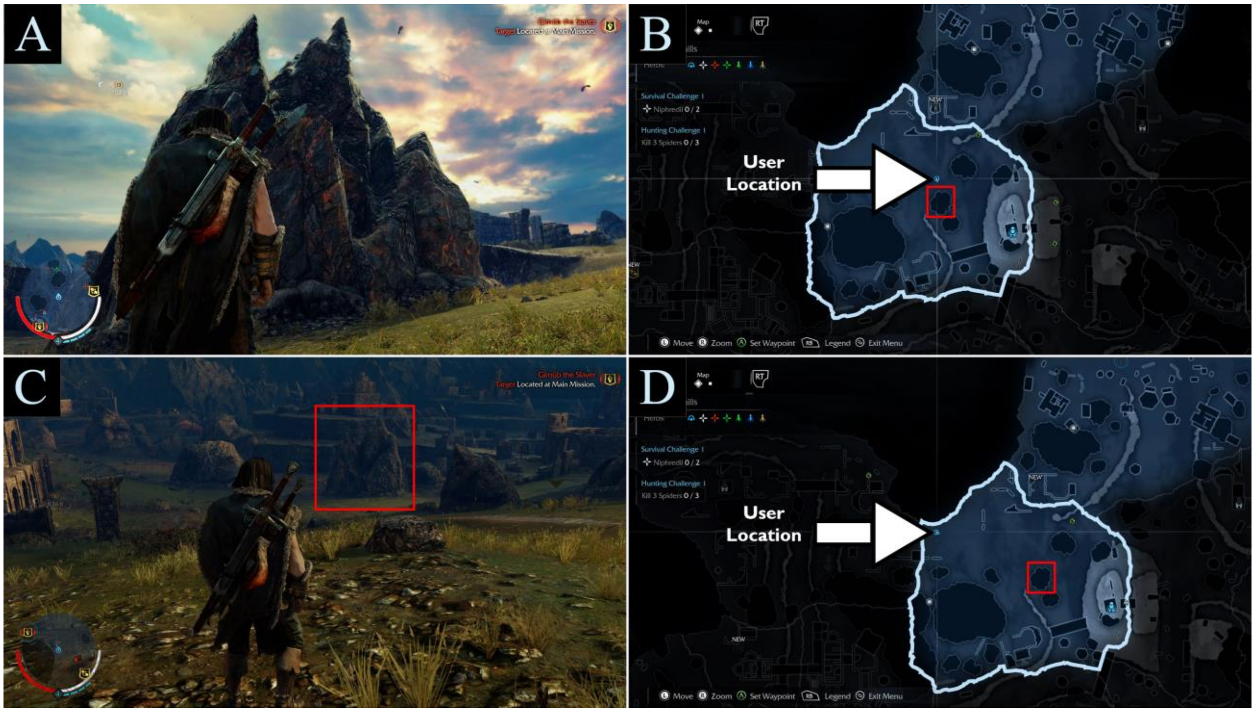



**Figure 4.4** ***Panning*** **the map with secondary interaction occurs when the avatar moves through the virtual world and the map centers on the avatar accordingly. The avatar in** ***Middle-Earth: Shadow of Mordor*** **(Monolith Production 2014) stands near a large rock (A) and at the center of the full-sized map when evoked with the same rock highlighted in red for reference (B). When the avatar moves away from the rock (C), the map re-centers on the avatar's location (D).**

*Resymbolize* and *overlay* were far more prevalent as secondary interactions than primary interactions, with fifty-nine maps allowing the user to *resymbolize* (59/68, 87%) and twenty-eight maps allowing the user to *overlay* (28/68, 41%) through secondary interaction. In contrast, only four maps permitted the player to *resymbolize* (4/63, 6%) and seven maps allowed the player to *overlay* (7/63, 11%) as primary interactions. This difference by interaction level is most likely to encourage the completion of the map through entertaining gameplay (i.e., secondary interaction with the avatar) over direct map use (primary interaction). Secondary *resymbolize* and *overlay* largely occurred when the avatar reached a vantage point or POI, spoke with a NPC, or discovered some other artifact in the virtual world (see Section 4.1.2 for discussion on unique UI features in playful maps).

There were no occurrences of *import, export, annotate, reexpress, arrange, sequence, reproject, filter, calculate, or search* as secondary interactions in the sample of video game maps. Overall, *import, export, reexpress, arrange, sequence, calculate, and search* were not present as either primary or secondary interactions. These operators, however, may prove useful in certain gameplay contexts, such as strategy games where many geographic features and situations are simultaneously visible to the player, and thus present future opportunities for video game map design.

### 4.1.2 Representing Interactivity

As discussed above, sixty-eight (68/71, 96%) of the video game maps supported secondary interaction through the avatar interface style and sixty-five (63/71, 89%) of the sampled maps permitted primary interaction through other direct and indirect interface styles. While no interface style for primary interaction was as prevalent as the avatar style for secondary interaction, indirect menu selection still was employed frequently as an interface style through primary interaction (50/63, 79%), with direct manipulation of the entire map (38/63, 60%) and direct manipulation of map features (35/63, 56%) also implemented in a majority of the sampled video game maps. The most prevalent UI features across the sampled maps were the YAH (69/71, 97%) and POI symbols (59/71, 83%). Finally, only twenty-four (24/71, 34%) of all maps provided learning materials to guide map use.

As introduced in Chapter 2, the interface style describes the manner that a given interaction operator is represented through visual affordances, with styles either enabling direct manipulation with map elements and linked widgets or indirect manipulation through text input or non-visual means. All secondary interaction through the avatar is a form of indirect manipulation of the map, since the avatar is in the virtual world and not part of the interactive map itself. Secondary interaction with the avatar was the most common interface style observed (68/71, 96%), and therefore presents a potentially new way to conceptualize mobile map design when the user replaces a virtual avatar. In other words, many operators conventionally implemented as direct manipulation interface styles in mobile maps (e.g., *pan*, *zoom*, *retrieve*) could potentially be more intuitive if evoked through gestures and other locomotive movements of the user, mimicking how an avatar interacts with the map in playful video games. Such indirect manipulation seems increasingly possible as non-visual sensors improve on mobile devices (Abraham forthcoming).

The most common interface style for primary interaction was indirect manipulation through menu selection (50/63, 79%). Shneiderman and Plaisant (2010) discuss the pros and cons of direct versus indirect styles for supporting work productivity: compared to direct styles, indirect menu selection has the advantages of constraining user interaction and reducing the learning curve (as all options are presented visually in the menu), but the limitations of consuming a greater amount of screen real-estate and having the danger of complex, nested windows that result in long interaction sequences. Thus, maps often use more direct styles than indirect, as direct interface styles provide more freedom in applying the interaction (Howard and MacEachren 1996). While common, the indirect menu selection interface style mostly was associated with the *save* operator, with 96% of all instances of indirect menu selection used for *save* (50/52). The other two examples of indirect menu selection were found in *Dota 2* (Valve Corporation 2013), where the player can *zoom* and *resymbolize* through a settings menu (Figure 4.5). Thus, while indirect menu selection was common across the sample, it was employed only for a small set of operators, primarily *save*.

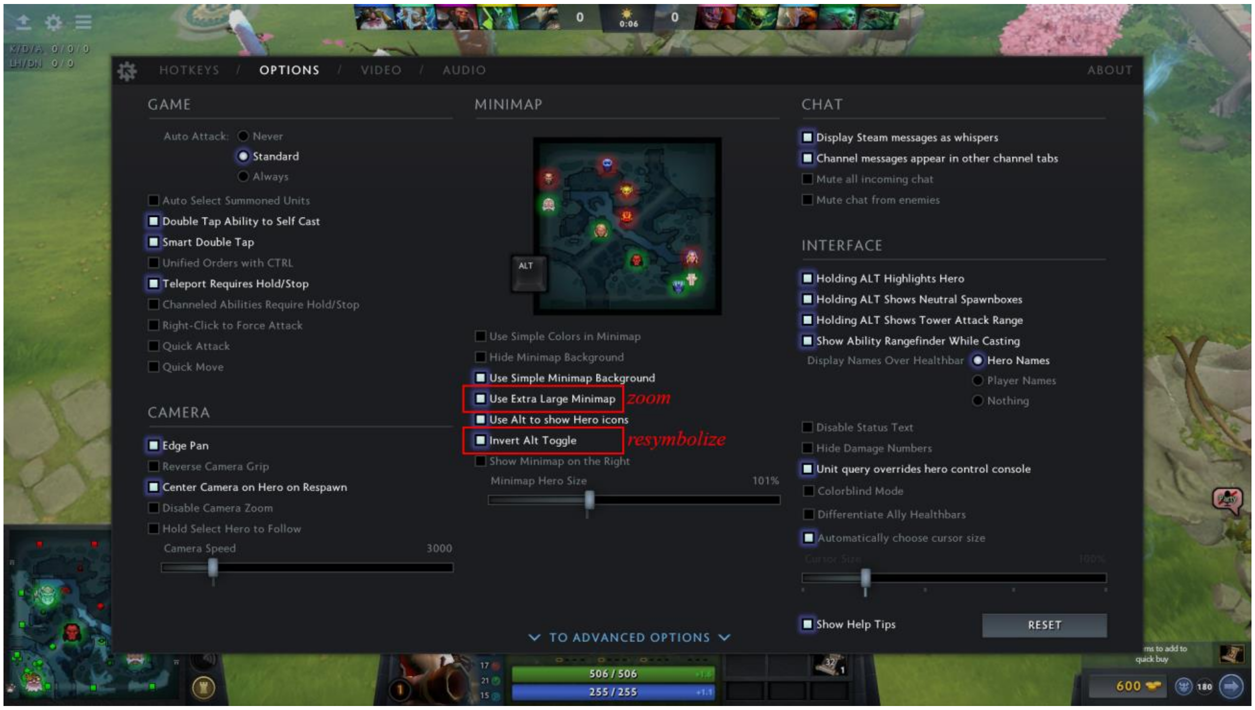



**Figure 4.5 While menu selection was mostly used for the *save* operator, the mini-map in *Dota 2* (Valve Corporation 2013) also allowed the user to change the size and scale of the map (i.e., *zoom*) and change the icons representing player-controlled characters (i.e., *resymbolize*).**

While less common than indirect manipulation, direct interface styles were leveraged in many video game maps: thirty-eight maps included direct manipulation of entire map (38/63, 60%), thirty-five included direct manipulation of map features (35/63, 56%), twelve included direct manipulation through a widget (12/63, 19%), six included direct manipulation through a linked isomorph (6/63, 10%), and four included direct manipulation through a map legend (4/63, 6%). Out of the forty-seven maps that provided either direct manipulation of map features or direct manipulation of the entire map, twenty-seven provided these two interface styles simultaneously (27/47, 57%), suggesting flexibility as a playful UI design guideline to enable the user to perform the same operator primitives in different ways based on game strategy.

Direct manipulation of widgets and legends were expectedly low, considering that the manipulation of these interface elements with a controller input device is not as intuitive as clicking with a mouse or tapping on a touch screen. I did not expect to find any examples of direct manipulation of the map through a linked isomorph. Linked isomorphs are common in cartography for complex visualizations with multiple, coordinated views of the information to support work productivity (Roberts 2008). However, six maps provided direct manipulation through linked isomorphs (6/63, 8%). Interestingly, in all six cases, the linked isomorphs were other maps within the game rather than a non-map visualization, with primary interaction in one map evoking linked interaction with another map. For instance, when clicking on any area of the mini-map in *Europa Universalis IV* (Paradox Development Studio 2013), the view of the superimposed map will *pan* to that location (Figure 4.6).

Direct interfaces were used for a wider range of primary interaction operators than indirect menu selection. Figure 4.7 shows interaction operators broken down by interface style. Out of the eleven interaction operators present in the sample maps, ten were supported through direct interfaces (10/11, 91%) while three were supported through indirect menu selection (3/11, 27%). By reinforcing interaction freedom through direct manipulation, playful maps in the sample adhere to recommendations of traditional cartography (Howard and MacEachren 1996, Shneiderman and Plaisant 2010).

Beyond interface styles, I also examined the visual variables used to encode unique UI features embedded in the video game maps, an important visual affordance for the 51% (36/71) of maps providing direct manipulation of map features (i.e., direct manipulation of unique UI features). As introduced in Chapter 2, unique UI features for playful video game maps include YAH symbols, vantage points, POI symbols, and NPCs.

YAH symbols were nearly ubiquitous across the sample, with sixty-nine maps depicting the avatar’s current location (69/71, 97%). The two maps that omitted the YAH symbol were


**Figure 4.6 In *Europa Universalis IV* (Paradox Development Studio 2013), *panning* in the superimposed map can be committed through the mini-map acting as a linked isomorph. In the lower right of the screen, the view of the superimposed map is represented by a white quadrilateral; when the player is viewing one part of the world (A), they can click on another part of the world in the mini-map, immediately *panning* to that location and updating the mini-map accordingly.**

intriguing, however. The first was a mini-map provided to the player when operating the Batmobile in *Batman: Arkham Knight* (Rocksteady Studios 2015) (Figure 4.8a). Like many mini-maps, this map is egocentric and always places the avatar at the center of the map, making symbolization of the avatar's location unnecessary. With this exclusion, the map adheres to the cartographic principles by omitting graphically redundant or useless information (Tufte 1983). The other map without a YAH symbol was a full-screen map artifact in *Dishonored 2* (Arkane

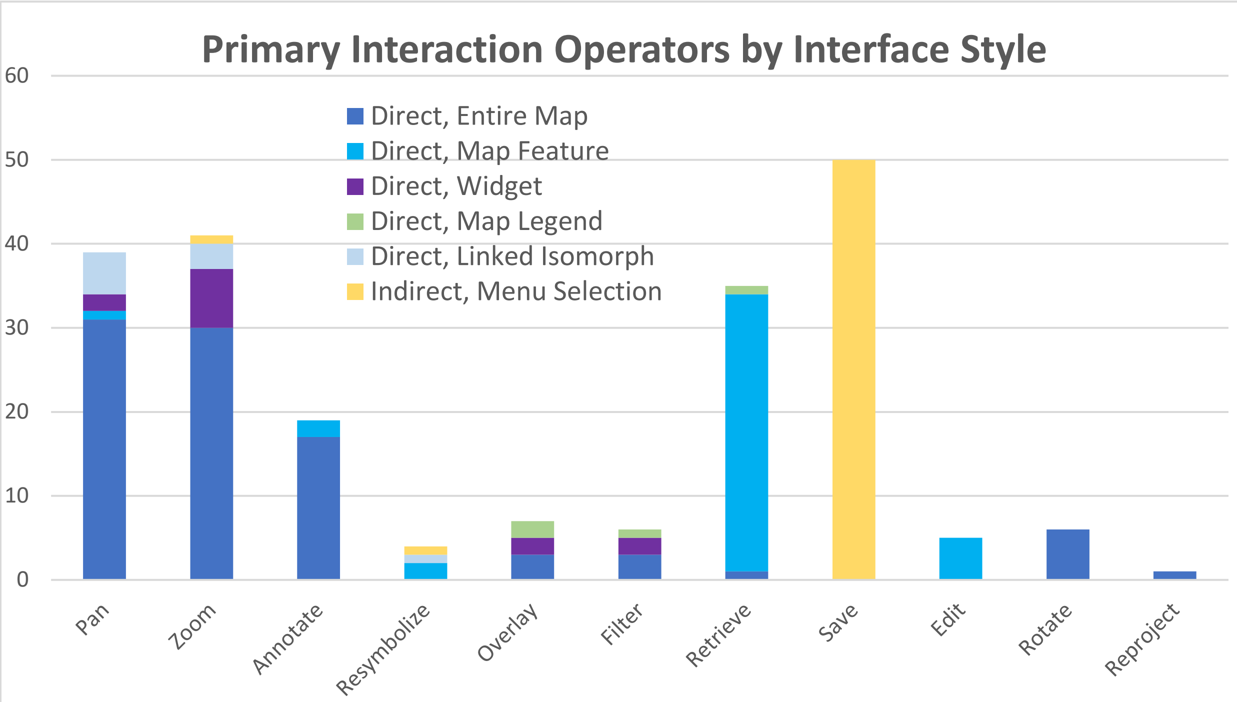



**Figure 4.7 Frequency of primary interaction operators by the interface styles. Interaction was supported through a variety of direct manipulation. However, *save* was the most prevalent operator and only supported through indirect menu selection.**

Studios 2016) (Figure 4.8b). Noteworthy for its stylistic congruence and that it must be acquired in the virtual world, this map artifact likely omits a YAH symbol to foster situated immersion by mimicking how a paper map would be used naturally by the avatar. Such a paper map would not provide a YAH symbol depicting the avatar's current location.

While maps with vantage points were not as prevalent as expected (11/71, 15%) (see Section 4.3 on UI feature incompleteness), POI symbols were common in the sampled video game maps (59/71, 83%). This was expected, as games often require the avatar to travel to different POIs in the virtual world and accordingly show those locations on the map. NPC symbols appeared in about half the sampled maps (35/71, 49%). This was expected, as knowing spatial information of characters in the virtual world can make the game less challenging (see Section 4.4 on UI feature inclusiveness). Interestingly, all UI features excepting NPCs were roughly equal when cross-referenced with map type, excluding superimposed and active maps

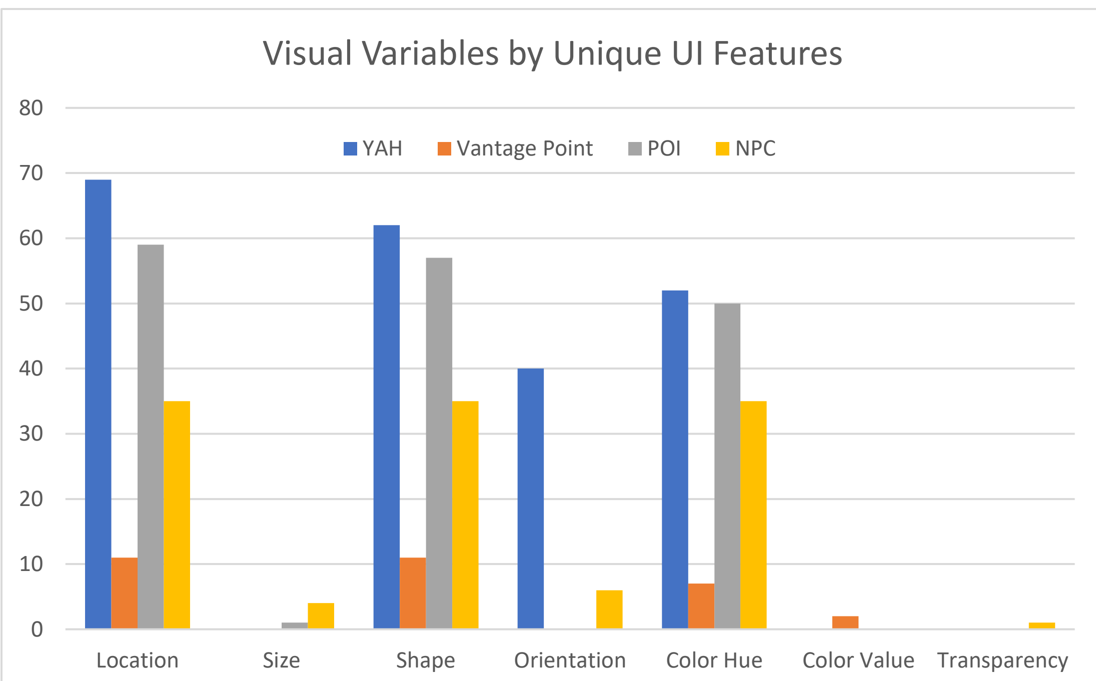

**Figure 4.8 Two maps in the sample excluded a YAH symbol. In *Batman: Arkham Knight* (Rocksteady Studios 2015), a YAH symbol is omitted as the map is egocentric and symbolizing the avatar's location is unnecessary (A). In *Dishonored 2* (Arkane Studios 2016), a YAH symbol would break situated immersion as a paper map used by the avatar in the virtual world would not show the avatar's location in real-time (B).**

due to the low frequency of each. Full-sized maps (31/71, 44%) and mini-maps (33/71, 46%) equally made up the vast majority of the sample (see Section 4.2 on map type and immersiveness). YAH symbols were present in 97% of both full-sized maps (30/31) and mini-maps (32/33), vantage points were present in 16% of full-sized maps (5/31) and 15% of mini-maps (5/33), POIs were present in 90% of full-sized maps (28/31) and 76% of mini-maps (25/33), and NPCs were present in in 16% of full-sized maps (5/31) and 73% of mini-maps

(24/33). This disparity in frequency of NPCs in full-sized maps and mini-maps suggests that full-sized maps are better suited for strategizing in-game movement over greater distances in the virtual world, while mini-maps tend to be used as quick reference tools for immediate gameplay tasks, showing what closely surrounds the avatar in the virtual world.

The visual affordances provided for unique UI features primarily employed the visual variables recommended for categorical rather than ordinal or numerical information (Bertin 1983, MacEachren 1995). Figure 4.9 depicts the frequency of each visual variable broken down by the UI feature they were used to represent. Out of sixty-nine maps that depicted YAH symbols, all used *location* to represent spatial information (69/69, 100%), while sixty-two used *shape* (62/69, 90%), fifty-two used *color hue* (52/69, 75%), and forty used *orientation* (40/69, 58%) to differentiate the YAH symbol from other map symbol categories. For vantage points, all symbols used *location* to represent spatial information (11/11, 100%), with eleven using *shape*

**Figure 4.9 Frequency of visual variables used to represent each unique UI feature. *Location* was used in every instance with *shape* and *color hue* the next most prevalent visual variables.**



(11/11, 100%) and seven redundantly using *color hue* (7/11, 64%) to differentiate vantage points from other categories. All POI symbols again used *location* to represent spatial information (59/59, 100%), with fifty-seven using *shape* (57/59, 97%), fifty using *color hue* (50/59, 85%), and one using *size* (1/59, 2%). Finally, all NPC symbols used *location* (35/35, 100%) to represent spatial information, also using *shape* (35/35, 100%), *color hue* (35/35, 100%), and to a lesser degree *orientation* (6/35, 17%), *size* (4/35, 11%), and *transparency* (1/35, 3%).

*Shape*¸ *color hue*, and *orientation* are the three commonly recommended visual variables for representing categorical differences, and thus are appropriate for distinguishing among nominal differences in kind of unique UI features. The POI and NPC symbols using *size* are particularly of interest, as *size* is recommended for numerical information to depict differences in magnitude. However, the use of *size* in this case had relatively minimal impact on gameplay: for instance, the map in *Pokémon Y* (Game Freak 2013) used *size* of POIs to depict towns as small symbols and cities as large symbols, much like how a reference map in the real world would depict different population levels (Figure 4.10). Overall, the representation of unique UI features in the video game maps conformed to recommendations in cartographic design.

Finally, learning materials were provided for only twenty-four of the sampled maps (24/71, 34%). Despite the fact that many video game maps depict fictitious worlds and the lack of standard interactive conventions in playful maps, overall map functionality and representation design does not vary widely from traditional maps. Thus, the infrequent use of learning materials is not surprising. Of these, the most prevalent type of learning material was the startup tip (17/24, 71%) activated at the beginning of the game. As reviewed by Mead (2014), startup tips provide a succinct introduction to key functionality, but are only accessible during first use (for playful maps, upon starting a new game) and thus are not helpful for continuous reference with more


**Figure 4.10 The map in *Pokémon Y (Game Freak 2013)* was one of the few maps where the visual variable *size* was used against cartographic recommendations. However, its use might warrant reconsideration in cartographic research.**

complex map visuals and interface functionality. Tutorials (3/24) and tooltips (3/24) each appeared in 13% of the sampled video game maps, while a single instance of narrated walkthrough was observed (1/24, 4%). Of the maps with learning materials, nineteen were presented as UI screens (19/24, 79%) while five were described through in-game dialogue with NPCs (5/24, 21%). The low prevalence of learning materials potentially marks one way that the design of traditional versus playful maps depart: playful maps, in their interactive designs, encourage the user to learn-by-doing rather than review training materials before or during gameplay. While this strategy may lead to lower work productivity at first, it promotes exploration of the virtual world, and ultimately creates a more immersive and enjoyable experience.

## 4.2 How Are Playful Maps Immersive?

The second category of codes examined the *immersive* characteristic of playful video game maps. I included three sets of codes for immersive cartographic interaction: the video game map type, the inclusion of the map as an in-game artifact, and the presence of metaphoric interaction within the map. I included five sets of codes to capture immersive representation through the map aesthetics: the development of a coherent style through form (i.e., linework), typography, color, and texture, and a binary signaling if these design choices support stylistic congruence with the video game environment, narrative, and characters. These categories and frequencies of each are listed in Table 4.2.

### 4.2.1 Immersion Through Interactivity

Full-sized maps (31/71, 44%) and mini-maps (33/71, 46%) together made up the vast majority of the sample, along with six superimposed maps (6/71, 8%) and one active map (1/71, 1%). In-game map acquisition was required to view ten of the sampled maps (10/71, 14%), with metaphoric interaction available in twenty-two of the maps (22/71, 30%). *Pan* (22/22, 100%) and *zoom* (8/22, 36%) were the most common operators implemented for metaphoric interaction. Most maps provided metaphoric interaction solely through secondary interaction (14/22, 64%).

I expected the full-sized maps (31/71, 44%) and mini-maps (33/71, 46%) to be the most common types of video game maps following Gekker's game map taxonomy (2016), and together they accounted for 90% of all game maps in the sample. This finding is a testament to the importance of diegetic immersion in video game maps using full-sized maps and mini-maps, as these map types are a part of the in-game UI or HUD, available for reference by the real-life

**Table 4.2 Descriptions of the codes used to evaluate immersiveness in the analysis. The count refers to the number of maps that included that particular code with the percentage compared against the total number of maps in the sample (n=71).**

| Category | Code | Definition | Count | % |
|---|---|---|---|---|
| Interactive Immersion | | | Count | % |
| map type | full-sized map | map that takes up the entirety of the screen, disabling other in-game actions | 31 | 44% |
| | mini-map | map that remains a part of the heads-up display | 33 | 46% |
| | superimposed map | map where the in-game entities and map features exist in the same space | 6 | 8% |
| | active map | map that allows other in-game actions and requires divided attention for use | 1 | 1% |
| map acquisition | map artifact | map is an acquirable in gameplay; may be any of the map types above | 10 | 14% |
| metaphor | natural metaphor | interaction provided in the map matches how the user expects the avatar would interact with the map | 22 | 31% |
| Representing Immersion | | | | |
| form | detailed | linework of map features shows more geographic information | 23 | 32% |
| | simplified | linework of map features is generalized | 44 | 62% |
| | accurate | linework of map features matches actual location in the game | 59 | 83% |
| | relative | linework of map features is not displayed with geographic accuracy but relative to other map features | 8 | 11% |
| | none | no linework for features | 4 | 6% |
| typography | presence | text (e.g., labels) appears on the map and map features | 15 | 21% |
| color | bold | colors are bright and exhibit great contrast | 20 | 28% |
| | muted | colors exhibit minimal contrast | 25 | 35% |
| | dark | colors have low brightness value | 26 | 37% |
| texture | presence | medium of the map interface uses texture | 25 | 35% |
| style | stylistic congruence | map graphically appears as the user would expect within the virtual world | 38 | 54% |

player during gameplay (i.e., supporting diegetic immersion) but disconnected from the virtual purview of the avatar (i.e., not supporting situated immersion). Thus, the majority of playful maps included in video games prioritize diegetic over situated immersion, suggesting that contemporary video game designers use maps as tools to immerse the player within the act of playing the game rather than the virtual world. However, a subset of games utilized interesting, alternative map-based strategies to promote situated immersion, as reviewed below.

The genre of the game proved to be important when cross-referenced with map type. Out of all sampled maps, twenty-nine were in action games (29/71, 41%), twenty-six were in adventure games (26/71, 37%), four were in process-oriented games (4/71, 6%), and twelve were in strategy games (12/71, 17%). Of the maps in action games, mini-maps (16/29, 55%) were more slightly popular than full-sized maps (13/29, 45%). However, in adventure games, full-sized maps (15/26, 58%) were slightly more prevalent than mini-maps (11/26, 42%). In process-oriented games, full-sized maps were most frequent (2/4, 50%), followed by one mini-map (1/4, 25%) and one active map (1/4, 25%). Finally, in strategy games, superimposed maps were the most popular (6/12, 50%) followed by mini-maps (5/12, 42%) and one full-sized map (1/12, 8%). While many of these frequencies were close, the preference of map types in game genres supports the finding in 4.1.2 that suggests different map types are potentially best suited for specific genres, considering game genres are defined by the nature of gameplay and the skills required for success (Egenfeldt-Nielsen et al. 2013, Gekker 2016).

Of the fifty (n=50) games included in the sample, twenty (20/50, 40%) had multiple maps, with one game including three maps. Eighteen of these games included both a full-sized map and mini-map (18/20, 90%). The overlap of these two map types suggests that full-sized maps and mini-maps are both effective at supporting the same type of immersion, as expected. This also suggests that some games in the sample contained gameplay that would fit into multiple genres defined by Egenfeldt-Nielsen et al. (2013), considering that full-sized maps and mini-maps potentially facilitate different kinds of gameplay.

While superimposed maps were not common (6/71, 8%), they were included in all six strategy games in the sample. Strategy games typically employ a ‘god-like’ view of the virtual world to allow the player to gain an overview of important geographic features within the game, explaining why maps that superimpose overview map context onto the virtual environment often are chosen for these games. For instance, the superimposed map from *Ultimate General: Gettysburg* (Game-Labs 2014) supports situated immersion simultaneously in the virtual world and map (Figure 4.11), mimicking how an army general might view and command armies on a strategic war map and how the soldiers would carry out these plans. Active maps are arguably best suited for situated immersion, as they require the player to divide attention between map use and avatar actions in the virtual world as real-world maps do. I was surprised to find only one (1/71, 1%) active map in the sample. The one active map was included in *Firewatch* (Campo Santo 2016), where it appears as a paper map held by the avatar in the virtual world, slowing the

**Figure 4.11 The god-like view of the superimposed map of *Ultimate General: Gettysburg* (Game-Labs 2014) supports situated immersion, providing an imaginative analogy to how a military leader would view a war map and strategize their soldiers.**

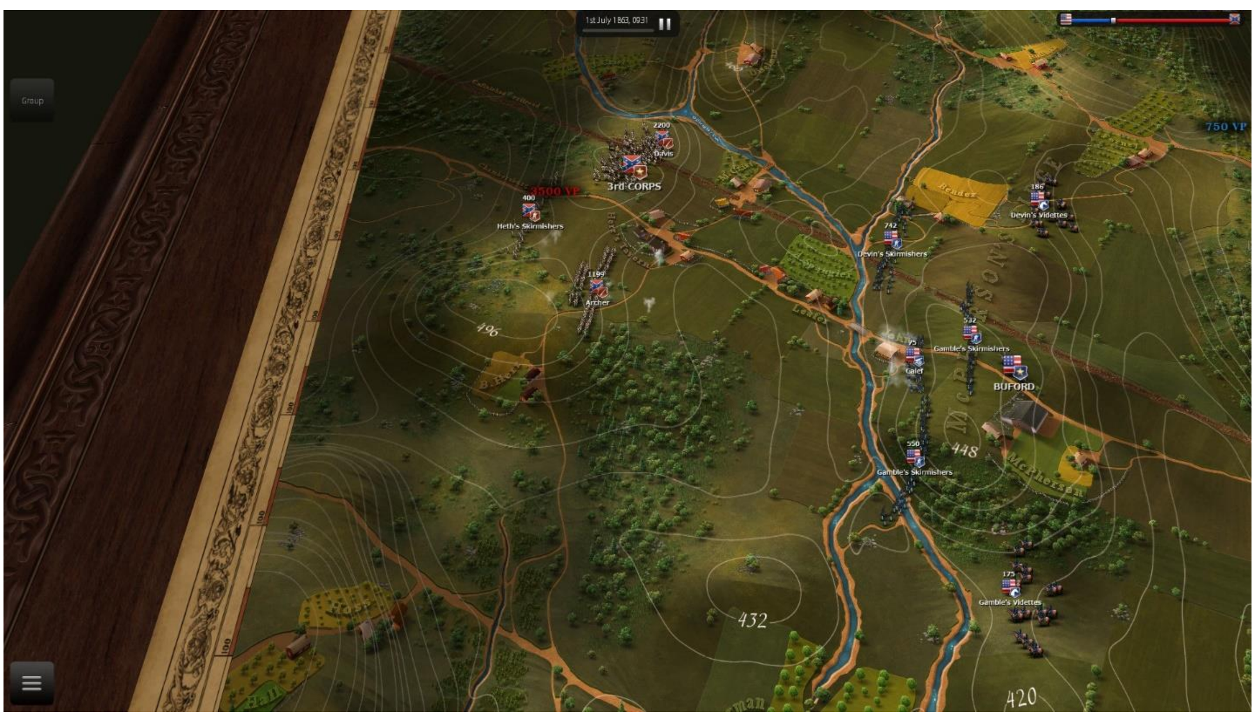



**Figure 4.12 The active map in *Firewatch* (Campo Santo 2016) appears in the hands of the avatar in the virtual world and restricts non-movement actions within the game, supporting situated immersion.**

avatar's movement and restricting in-game interactions, similar to map use in the real world (Figure 4.12). The scarcity of active maps in the sample suggests that many game designers support situated immersion through map design choices other than interaction (see Section 4.2.2 for discussion on immersiveness through representation design).

Only ten maps were acquired through gameplay as map artifacts (10/71, 14%). The frequency of map acquisition was lower than expected and further points to the underutilization of interaction as a method for situated immersion. Arguably, the video games that included map acquisition better promoted situated immersion through map-avatar interaction in the virtual environment. For instance, the map artifact in *Dishonored 2* (Arkane Studios 2016) is found on a wall in the virtual world and is only accessible as a full-sized map after the avatar has discovered it (Figure 4.13). Spatial information of a new area is unknown to the player and avatar until the map is acquired. This is similar to the real world, where a map aids a user when navigating in an

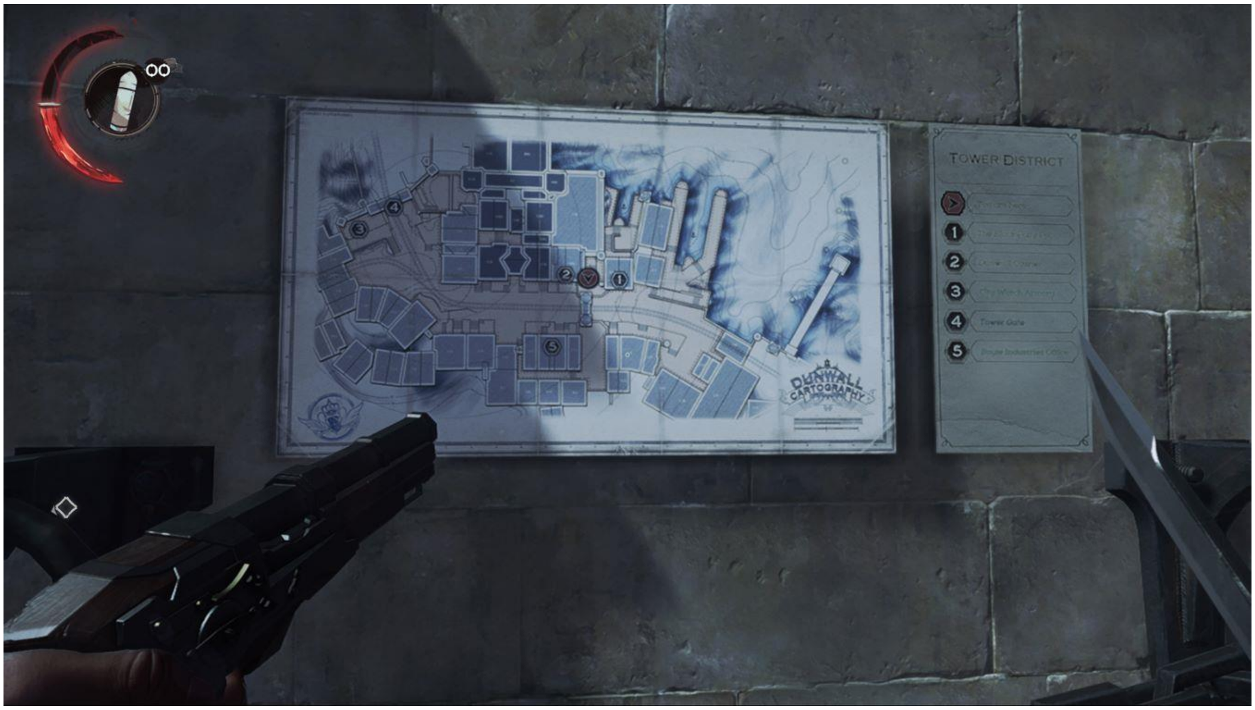



**Figure 4.13 Map artifacts like those found in *Dishonored 2* (Arkane Studios 2016) support situated immersion by hiding spatial information until the avatar acquires the map for the surrounding area. The map is found on a wall in the virtual world and subsequently is accessible through the start menu.**

unknown area, thus, immersing the player in the role of the avatar through the acquisition of the map.

Finally, the lack of situated immersion through interaction also was indicated by the infrequent use of natural metaphors for interaction operators (22/71, 31%). Natural metaphors implement map-player primary interaction or map-avatar secondary interaction in a manner consistent with how a real-life map user would interact with a traditional map (Cartwright et al. 2001), such as the wrist-bound digital map in *Fallout 4* (Bethesda 2015) (Figure 4.14). Natural metaphors were implemented for primary interaction in five maps (5/22, 23%), as secondary interaction in fourteen maps (14/22, 64%), and as both primary and secondary interactions in three maps (3/22, 14%), altogether suggesting that situated immersion through natural metaphor is more easily supported through interactions evoked by the avatar. *Pan* (22/22, 100%) and *zoom* (8/22, 36%) were the most common operators implemented using natural metaphors, with


**Figure 4.14 Interactions in *Fallout 4* (Bethesda 2015) appear as though the avatar is committing them. This is reinforced by the map's existence as a part of the in-game device that the avatar wears on their wrist and the presence of the avatar's hand adjusting dials in the interface.**

*retrieve* (3/22, 14%), *annotate* (2/22, 9%), and *overlay* (1/22, 5%) also implemented naturally in a small set of maps. These operators are common in real-world web maps, making them suitable choices for natural metaphors in playful maps.

Overall, situated immersion through interactivity was underutilized across the sample of video game maps. Future research is needed on interactive maps that support situated immersion in playful contexts such as video games, but also in work contexts using virtual and augmented reality. While situated immersion in video game maps encourages the user to keep playing and exploring the virtual world, situated immersion in traditional maps promoting work productivity could lead to higher memorability of information within the map as well as improved user satisfaction (Alavesa et al. 2017).

**4.2.2 Representing Immersiveness**

My treatment of representing immersiveness focused on the video game maps' aesthetic styles, broken into form (i.e., the linework style), typography, color, and texture. Starting with form, accurate linework was more common among the maps (59/71, 83%) than relative linework (8/71, 11%), and more maps exhibited simplified linework (44/71, 62%) than detailed linework (23/71, 32%). Four maps were completely absent of basemap linework (4/71, 6%), instead depicting UI symbols on top of a semi-transparent background. Next, persistent typography (i.e., labels that do not have to be *retrieved* through information popups) was present in fifteen sampled maps (15/71, 21%), with fifty-six maps not including labels (56/71, 79%). Regarding color, a monochromatic color palette was the most popular across the map sample (32/71, 45%), but was not much more prevalent than the other color palettes: dark (26/71, 37%), muted (25/71, 36%) and bold (20/71, 27%). Finally, explicit use of texture was used to mimic a certain map medium in twenty-six maps (26/71, 36%). Overall, only thirty-nine (39/71, 53%) of the maps were stylistically congruent to what the user might expect the avatar to use in the virtual world.

The majority of maps (67/71, 94%) included non-interactive basemap context for interpreting the interactive UI features and facilitating map reading. The basemap form reinforces the game theme as well as suggests how the map should be used, and thus can promote both diegetic and situated immersion. I coded for two general categories of form, resulting in four possible styles of basemap linework: spatial accuracy (i.e., accurate vs. relative) and complexity (i.e., detailed vs. simplified). Most of maps used accurate yet simplified form (36/67, 54%), providing exact locations but in relatively low detail. Twenty-three maps were accurate and detailed (23/67, 34%), eight were relative and simplified (8/67, 12%), and none were relative and detailed (a perhaps illogical combination). Considering the map is not typically the centerpiece of the game and is often used as a tool to guide spatial play, these findings suggests that simple, accurate linework successfully supports simple tasks like wayfinding. For instance, the full-sized map in *The Swapper* (Facepalm Games 2013), shows the general outline of navigable underground chambers in their exact positions in the virtual world (Figure 4.15). Arguably, the accurate yet simple linework style also characterizes most web and mobile maps designed for wayfinding, with the map depicting only the information relevant to the users' tasks in high accuracy. Thus, most video game maps emphasize wayfinding through their linework design, rather than using form for diegetic or situated immersion.

Typography provides additional context for map symbols, and also can reinforce the game setting and time period through purposeful selection of typefaces. Typography was present in fifteen (15/71, 21%) of the sample maps. Of these, ten were full-sized maps (10/15, 67%), three were superimposed maps (3/15, 20%), one was a mini-map (1/15, 7%), and one was an active map (1/15, 7%). The low frequency of persistent typography in full-sized maps suggests that the inclusion of type is simply a reflection of the screen real-estate occupied by the map, rather than an aesthetic choice for supporting immersion through representation, again pointing to a missed opportunity for using map aesthetics in video games.

Color evokes strong emotional reactions, and often is an important stylistic choice in map design. A visually pleasing color palette can increase the likability of a map (Fabrikant et al. 2012), potentially encouraging players to view and use the map more often, supporting diegetic immersion. A game designer also can apply a color palette to support situated immersion by selecting colors that match the setting, time period, and technological infrastructure of the video game world (Knoppke-Wetzel 2014). Interestingly, the use of color varied substantially across the sample, with dark (26/71, 37%), muted (25/71, 35%), and bold (20/71, 28%) palettes each

**Figure 4.15 The full-sized map in *The Swapper* (Facepalm Games 2013) provides a simplified yet accurate representation of the virtual world, prioritizing the map's role as a navigational and reference tool.**


observed in roughly one-third of the sample. This variability was unexpected and suggests that color was the most utilized stylistic element of playful maps employed in video games to support both diegetic and situated immersion. Figure 4.16 shows how different color palettes were used in *Europa Universalis IV* (Paradox Development Studio 2013), *The Witcher III: Wild Hunt* (CD Projekt RED 2015), and *Titanfall 2* (Respawn Entertainment 2016) to support immersion. The bold color choice in *Europa Universalis IV* may be unrealistic, but it allows for easy distinction between political powers, supporting seamless gameplay and diegetic immersion. The muted color palette in *The Witcher III: Wild Hunt* and the dark color palette in *Titanfall 2* are stylistically congruent to what the player would expect in a map of each game's virtual world, supporting situated immersion. In addition to color palettes, textures were used to support situated immersion, mimicking the medium that a map in the virtual world would appear in (e.g., wrinkled paper). Twenty-five (25/71, 35%) maps used textures to mimic a certain medium to support situated immersion. This was slightly lower than expected, indicating an area where video game designers could improve situated immersion through representation.


**Figure 4.16 Color in video game maps can be leveraged to support both diegetic and situated immersion. Bold color in *Europa Universalis IV* (Paradox Development Studio 2013) allow for easy distinction between countries, supporting diegetic immersion (A). The muted color palette in *The Witcher III: Wild Hunt* (CD Projekt Red 2015) (B) and the dark color palette in *Titanfall 2* (Respawn Entertainment 2016) (C) support situated immersion, styling the map just as the user would expect in the virtual world of the avatar.**

Finally, I considered form, typography, color, and texture altogether to judge how well the cartographic representation supported situated immersion through stylistic congruence with the game's virtual world. In total, thirty-eight of sampled maps supported stylistic congruence (38/71, 54%), a somewhat smaller frequency than expected. While over half of the sampled video game maps supported situated immersion through aesthetic style, thirty-three (33/71, 46%) of the sampled maps missed this opportunity. Thus, developing congruent aesthetic map styles is one aspect of video gaming where designers can learn from cartographers to build greater situated immersion.

## 4.3 How Are Playful Maps Incomplete?

The third category of codes examined the *incomplete* characteristic of playful maps in video games. I included two sets of codes regarding interaction incompleteness: the primary and secondary levels of cartographic interaction and the operators used to complete a map at each level. I also included two sets of codes to capture how incompleteness is represented cartographically: incomplete by *feature*, investigating if unique video game UI features could become complete and the playful method through which feature completeness is achieve, and incomplete by *extent*, examining the presence of fuzzy boundaries and the playful method through which extent completeness is achieved. These categories and frequencies of each are listed in Table 4.3.

### 4.3.1 Completing the Map with Interactivity

Fifty-one of the sampled maps (51/71, 72%) could be completed through secondary interaction, but, surprisingly, none of the sampled maps allowed the player to complete the map through primary interaction. Thus, map incompleteness is a driving force for encouraging

**Table 4.3 Descriptions of the codes used to evaluate incompleteness in the analysis. The count refers to the number of maps that included that particular code with the percentage compared against the total number of maps in the sample (n=71).**

| Category | Code | Definition | Count | % |
|---|---|---|---|---|
| Completing the Map with Interactivity | | | Count | % |
| operators | pan | change the geographic center of the map | 34 | 48% |
| operators | zoom | change the scale of the map | 0 | 0% |
| operators | annotate | add graphic markings and/or textual notes to map | 0 | 0% |
| operators | resymbolize | change design parameters of map features | 45 | 63% |
| operators | overlay | adjust (i.e., toggle visibility) of map features | 19 | 27% |
| operators | filter | identify map features meeting certain criteria | 0 | 0% |
| operators | retrieve | request specific details about map features | 0 | 0% |
| operators | save | store the geographic information of map | 0 | 0% |
| operators | edit | manipulate geographic information underyling the map | 0 | 0% |
| operators | import | load geographic information or previously generated map | 0 | 0% |
| operators | export | extract geographic information or generated map | 0 | 0% |
| operators | calculate | derive new information about map features of interest | 0 | 0% |
| operators | search | identify a particular location or map feature of interest | 0 | 0% |
| operators | reexpress | change the visual cartographic isomorph | 0 | 0% |
| operators | arrange | manipulate the layout of views | 0 | 0% |
| operators | sequence | generate an ordered set of maps | 0 | 0% |
| operators | reproject | change the map projection or orientation | 0 | 0% |
| levels | primary | interaction committed through the cartographic interface and traditional controls in the virtual environment | 0 | 0% |
| levels | secondary | interaction committed through gameplay and controlling entities within the virtual world | 51 | 72% |
| Representing Incompleteness | | | | |
| feature | you-are-here symbol | symbol depicting the avatar within the virtual world becomes complete in the map (through vantage point or symbol discovery) | 0 | 0% |
| feature | point of interest (POI) | locations in the virtual world that hold significance to gameplay (e.g., cities, fortresses, dungeons) become complete in the map (through vantage point or symbol discovery) | 2 | 3% |
| feature | vantage points | locations in the virtual world where the user must reach to add more geographic information to the map become complete in the map (through vantage point or symbol discovery) | 38 | 54% |
| feature | non-player character (NPC) | entities within the game whose actions are pre-programmed in and controlled by the game (e.g., monsters townsfolk) become complete in the map (through vantage point or symbol discovery) | 11 | 15% |
| extent | fuzzy boundary | separation of discovered and undiscovered areas using visual variables (through vantage point or symbol discovery) | 33 | 46% |
| method | vantage point | symbols on the map become complete by reaching vantage points during gameplay | 40 | 56% |
| method | symbol discovery | symbols on the map become complete through real-time exploration | 11 | 15% |

gameplay through the avatar but was not realized through primary interaction in the sampled maps.

Overall, this finding regarding incompleteness provides further evidence that avatar-based secondary interaction is fundamental to playful map design. Further, future research on secondary interaction for addressing incompleteness also is warranted for traditional maps

supporting work productivity, given the relatively large interest in the representation of uncertainty in cartography and related fields.

The incompleteness of playful maps is a major proponent of playful exploration in a video game. Of the fifty-one maps that could be completed using secondary interaction, twenty-seven were full-sized maps (27/51, 53%), eighteen were mini-maps (18/51, 35%), five were superimposed maps (5/51, 10%), and one was an active map (1/51, 2%). Interestingly, the vast majority of all full-sized maps were incomplete (27/31, 87%), while only about half of all mini-maps were incomplete (18/33, 55%). This suggests that mini-maps typically reflect only what the avatar sees in the surrounding geography, situating the player within the virtual world through the avatar's eyes. Full-sized maps, however, embed more elements of gameplay, such as incom plete features and areas.

Forty-five incomplete maps used *resymbolize* (45/51, 88%), thirty-four used *pan* (34/51, 67%), and nineteen used *overlay* as interaction operators to complete the map (19/51, 37%) (Figure 4.18). About 94% (32/34) of instances where *pan* completed the map were coincident with *resymbolize* also being used to complete the map, confirming that symbol discovery often manifests through the combination of these two operators. For instance, in *Borderlands 2* (Gearbox Software 2012), as the user *pans* across the map through secondary interaction, POI symbols *overlay* on the map (Figure 4.17). It is common for a single interaction with a traditional map to evoke multiple operators (e.g., *pan* and *zoom* when double-clicking/tapping a map). However, these combinations often are conventional or must be learned through help instructions. Thus, the combination of *pan* with *overlay* and *resymbolize* for feature completion through secondary interaction may be a first design convention unique to playful maps. No other operators were used to complete the map across the sample.

**4.3.2 Representing Incompleteness**

The visual variables again were applied to examine the visual affordances used to represent incomplete UI features unique in video game maps and an incomplete overall map extent. Of the incomplete maps, POIs (38/51, 76%) were the most prominent feature that could be completed, with completion of NPCs (11/51, 22%) and vantage points (2/51, 4%) less common. There were no instances of maps where the YAH was incomplete and could be completed through interaction. Thirty-three (33/51, 65%) of the incomplete maps were incomplete by extent and used *crispness* (19/33, 58%), *color value* (17/33, 52%), *transparency* (8/33, 24%), *color hue* (7/33, 21%), or *texture* (4/33, 4%) to represent this incompleteness. Symbol discovery in the virtual world was far more popular (40/51, 78%) than vantage points (11/51, 22%) as a method for map completion.

Visual affordances used for incomplete features relates to research in cartography on visualizing uncertainty of point features (e.g., MacEachren et al. 2012). Forty-one of incomplete maps were incomplete by feature (41/51, 80%) and thirty-three were incomplete by extent (33/51, 65%). The prevalence of these types of incompleteness suggest that uncovering new geographic knowledge is key to gameplay, with knowledge of point-type objects within the virtual world (represented by the unique UI features) slightly more important than knowledge of the navigable virtual world. Maps where POI symbols could be completed were the most


**Figure 4.17 As the user *pans* through secondary interaction in the full-sized map of *Borderlands 2* (Gearbox Software 2012) (A), new symbols are *overlaid* on the map (B). These tandem operators enable the player to the complete the map.**

prevalent (38/51, 76%), followed by NPC symbols (11/51, 22%) and vantage points (2/51, 4%). Neither of the two maps that initially lacked a YAH symbol could be completed during gameplay. While I expected maps with completable YAH symbols to be rare, I did not expect them to be absent in the 2012-2016 range, given the pervasiveness of adding a YAH symbol through acquisition of a dungeon map and compass in classic game franchises such as *The Legend of Zelda* (Nintendo 1986-2017) as well as new critically-acclaimed games like *Hollow Knight* (2017). This finding outlines where contemporary game designers can drive gameplay through incompleteness of the YAH symbol, requiring the player to commit in-game actions that make navigation and gameplay easier.

The relative use of symbol discovery versus vantage points as a map completion method also was surprising. As mentioned Section 4.1.2, vantage points were uncommon in the sample, and only eleven of the incomplete maps utilized them as a completion method (11/51, 22%). Vantage points require more effort to reach, a task that some players might find frivolous. Vantage points also break up continuous gameplay, which could cause the player to lose situated or diegetic immersion in the game.

The majority of maps that were incomplete by extent used *crispness* (19/33, 58%) to symbolize the boundary between discovered and undiscovered areas, upholding the concept of fuzzy boundaries in playful maps (Fraser and Wilmott 2016) and adhering to the recommended use of *crispness* to represent uncertainty (MacEachren 2005, MacEachren et al. 2012). *Color value* was used to represent completeness by extent in seventeen maps (17/33, 52%), making the map resemble a land shrouded in fog (high color value) or darkness (low color value) to indicate uncertainty, and *transparency* in eight maps (8/33, 24%). Both *color value* and *transparency* also are recommended for representing uncertainty (MacEachren et al. 2012). However, a subset of maps violated cartographic recommendations for representing incompleteness: seven maps used *color hue* (7/33, 21%) and four used *texture* (4/33, 12%), suboptimal visual variables for uncertainty. However, the use of these visual variables for uncertainty in playful maps may warrant reconsideration in traditional maps for work productivity. Thus, overall the representation of certainty followed cartographic design recommendations, with slightly more inconsistency for representing incompleteness.

## 4.4 How Are Playful Maps Inclusive?

The final category of codes examined the *inclusive* characteristic of playful maps in video games. I applied four sets of codes regarding cartographic interaction: single-player versus multiplayer game modes, the four spatiotemporal contexts for geocollaboration (same/different place/time), support of geocollaboration through primary and secondary interaction, and provision of information about other player avatars through completion of the map (as an extension of Section 4.3.2). I also applied one set of codes for cartographic representation: the representation of characters, both player-controlled and non-player, on the map during multiplayer gameplay. These categories are listed in Table 4.4.

### 4.4.1 Inclusive Interactivity

At the core of playful inclusivity is the interaction among multiple real-life players in the virtual world. Thus, video game maps were considered as inclusive only if they could be manipulated by multiple real-life players. Thirty-one of the sampled game maps were inclusive, multiplayer maps (31/71, 44%). Interestingly, all of these maps supported different-place/same-

time geocollaboration (31/31, 100%), with support for same-place/same-time (7/31, 23%), same-place/different-time (1/31, 3%), and different-place/different-time (1/31, 3%) contexts considerably less common in the sample. Collaboration through secondary interaction (17/31, 55%) was more prevalent than collaboration through primary interaction (10/31, 32%), an indication of the importance of avatars in multiplayer video games. Ten inclusive game maps (10/31, 32%) allowed a player to discover information about other player-controlled entities as part of incomplete gameplay.

As introduced in Chapter 2, inclusive maps can support playful competition and collaboration in the same or different real-world places as well as the same or different real-world times, resulting in four spatiotemporal contexts. Frequencies of each context are visualized in Figure 4.22. Interestingly, geocollaboration in the different-place/same-time context was supported by every inclusive map (31/31, 100%). This frequency of synchronous geocollabor ation at different locations is largely due to the ubiquity and robustness of internet connectivity in modern gaming consoles (Ahlqvist 2011). Therefore, playful maps supporting different-place/same-time inclusion require additional visual affordances and interactive functionality that assist players in collaborating in real-time when not physically present in the same space. Same-place/same-time geocollaboration was supported in seven inclusive maps (7/31, 23%). Gameplay for same-place/same-time and different-place/same-time geocollaboration was largely consistent in game rules and interactive functionality, with the primary exception the splitting of the screen in same-place/same-time to accommodate the viewpoints of multiple real-life players using the

**Table 4.4 Descriptions of the codes used to evaluate inclusiveness in the analysis. The count refers to the number of maps that included that particular code with the percentage compared against the total**

| Category | Code | Definition | | |
|---|---|---|---|---|
| | | Interactive inclusiveness | Count | % |
| game type | singleplayer | game offers play for one player | 68 | 96% |
| | multiplayer | game offers play for more than one player | 31 | 44% |
| collaboration contexts | same place/same time | collaboration that occurs at the same geographic location and at the same time | 7 | 10% |
| | same place/different time | collaboration that occurs at the same geographic location and at different times | 1 | 1% |
| | different place/same time | collaboration that occurs at different geographic locations and at the same time | 31 | 44% |
| | different place/different time | collaboration that occurs at different geographic locations and at different times | 1 | 1% |
| levels | primary | collaborative interaction committed through the cartographic interface and traditional controls in the virtual environment | 10 | 14% |
| | secondary | collaborative interaction committed through gameplay and controlling entities within the virtual world | 17 | 24% |
| incomplete | completion | locations of other players are not always present on the map but can be unlocked through some interaction | 10 | 14% |
| | | Representing inclusiveness | | |
| entities | allies | presence of other player-controlled entities that are working with the player to achieve a common goal | 26 | 37% |
| | enemies | presence of other player-controlled entities that are working against the player to achieve an opposing goal | 18 | 25% |
| | NPCs | presence of non-player controlled entities that exist in the game alongside player-controlled entities | 25 | 35% |

same display device. In this way, it is possible that different-place/same-time actually may offer greater diegetic and situated immersion through expanded visuals and lack of non-game, real-world, player-to-player interaction, an interesting comment on how web-enabled maps embedded in video games has changed the interpersonal experience of place.

Same-place/different-time (1/31, 3%) and different-place/different-time (1/31, 3%) geocollaboration were supported in only one video game map in the sample—*Mario Kart 8* (Nintendo 2014)—although this example provided a notable visual solution for multiplayer, different-time competition and collaboration. *Mario Kart 8* allows users to racing against the personal records of other players. During these races, a “ghost” avatar travels the exact route as a player who already completed the course (Figure 4.18). This racing mode is possible against a player account on the same game system (same-place) or through an internet connection (different-place). Such a ‘ghost’ or ‘trace’ solution serves as a dynamic visual benchmark during gameplay to inform competition and collaboration and is potentially applicable to other different-time geocollaboration design for work productivity as well as spatiotemporal visualization broadly.

Eighteen of the inclusive maps in the sample allowed for collaborative interaction (18/31, 58%). Seventeen of these maps supported collaborative secondary interaction (17/18, 94%) and ten supported collaborative primary interaction (10/18, 56%). The emphasis on secondary over primary interaction suggests that game designers expect players to collaborate with the map largely through gameplay with the avatars, potentially because online games that foster different-place/same-time geocollaboration cannot be paused. Thus, secondary interaction was more common than primary interaction in all observed codes, supporting immersion, incompleteness, and inclusiveness. Such a finding reinforces primary versus secondary interaction as a design concept in cartography, and suggests future research, particularly in mobile contexts, to better understand secondary interaction via the avatar or physical user for both playful and traditional map design.

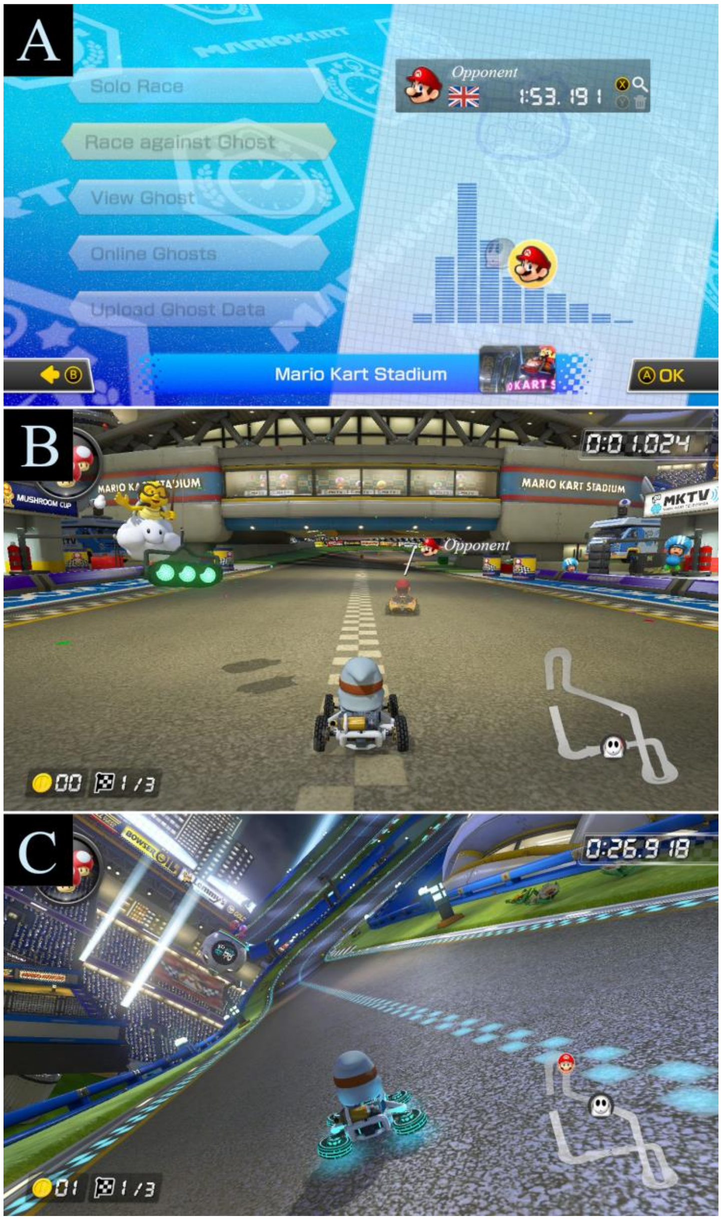



**Figure 4.18 In *Mario Kart 8* (Nintendo 2014), the player can compete against other human players in a geocollaborative different-place/different-time context. The player can select which course and another player's personal record they wish to beat. In-game, the opposing player is represented by a transparent avatar (referred to in-game as a 'ghost') that follows the exact route the player took when they drove the course. The location of the current player and the 'ghost' player are both symbolized on the map.**

Ten of the sampled inclusive maps allowed players to unlock information about other player-controlled avatars in the virtual world (10/31, 32%), with the maps using similar design solutions for representing incompleteness as reported in Section 4.3.2. Collaboration in these maps was supported through primary interaction in ten maps (10/31, 32%) and secondary interaction in seventeen maps (17/31, 55%).

### 4.4.2 Representing Inclusiveness

Twenty-six of the inclusive video game maps represented player-controlled allies (26/31, 84%), seventeen represented player-controlled enemies (18/31, 55%), and twenty-five represented NPCs who represent a ‘computer’ player (25/31, 81%). All representations of player-controlled allies (26/26, 100%), player-controlled enemies (18/18, 100%), and NPCs (25/25, 100%) used *location* to represent spatial information about the player and *color hue* to differentiate among different types of players. *Shape* and *color hue* were frequently used redundantly across players, following recommendations from cartographic design for representing categories.

The relative difference in frequency between player-controlled allies (26/31, 84%) and NPCs (25/31, 81%) versus player-controlled enemies (18/31, 58%) is not surprising, as many multiplayer games require the player to find opponents as a part of gameplay and thus leave enemy locations as an incomplete component of the map. Regarding geocollaboration, this also suggests that the purpose of inclusive maps in video games is to directly support collaboration through explicit symbolization of allies working together, but then to serve as an exploratory space to strategize about unknown enemies. Further, symbolizing allies rather than enemies also supports situated immersion, mimicking real-world situations where enemy information is not likely to be known.

Regarding representation of inclusive UI features, *location* and *color hue* were used to represent player-controlled allies (26/26, 100%), player-controlled enemies (18/18, 100%), and NPCs (25/25, 100%) in every map that included depicted those entities. Throughout, *location* was used to represent spatial information and *color hue* to differentiate among types of players. *Shape* was redundantly applied with *color hue* in many of the sampled maps, representing allies in nineteen maps (19/26, 73%), enemies in eleven maps (11/18, 61%), and NPCs in eighteen maps (18/25, 72%).

Interestingly, *orientation* was used to represent allies in fifteen maps (15/26, 58%), but enemies in only four maps (4/18, 22%) and NPCs in only three maps (3/25, 12%). In these examples, *orientation* was used to represent categorical, ordinal, and numerical information. *Orientation* effective most effective when depicting categorical information and less effective when representing numerical and ordinal information (MacEachren 1995). The use of *orientation* to nominally distinguish between players adhered to traditional cartography. Additionally, ordinal information often was used to depict relative verticality of other characters in the game. Finally, *orientation* was used to represent numerical information, typically the direction in which the avatar is facing (i.e., the player's line-of-sight in the virtual world). As mentioned above, finding the location of the opponent is crucial to success in competitive games. Additionally, if the player can see an enemy before the enemy sees them, the player has an advantage and can make the first offensive move. While knowledge of an ally's in-game line-of-sight is relatively unhelpful, knowing the enemy's line-of-sight can make a difference in successful or unsuccessful in-game strategy. Thus, knowing the line-of-sight of an enemy player in the virtual world is useful to avoid being seen, but requires less caution, reducing the satisfying challenge of the game.

Similar to the use of visual variables to represent unique UI features discussed in 4.1.2, overall representation of players and NPCs in inclusive maps conformed to recommendations in cartography and design. However, there were several uses of *transparency* and *size*: *transparency* was used twice for allies (2/26, 8%), once for enemies (1/18, 6%), and once for NPCs (1/18, 6%) while *size* was used twice for allies (2/26, 8%), three times for enemies (3/18, 17%), and twice for NPCs (2/25, 8%). *Transparency* and *size* are recommended for ordinal and numerical information, respectfully, and thus represented attributes of the players that dynamically changed during gameplay, such as relative vertical location (as discussed in subsection 2.4.2).

# Chapter 5: Discussion and Future Directions

## 5.1 Summary of Results

This research investigated how playful maps in video games conform to and diverge from traditional cartographic tenets, identifying where cartography could inform playful map design and vice versa with the following research questions:

RQ #1: *How do video game maps exhibit interactivity, immersiveness, incompleteness, and inclusiveness of playful maps through traditional cartographic frameworks?*

RQ #2: *How do video game maps utilize elements of interaction and representation as cartographic tools for play?*

To answer these questions, I first conducted a review of literature on cartography, design, play, and video games. Leveraging frameworks from the literature, I analyzed 71 maps from 50 video games from 2012 to 2016 with QCA. The results of this thesis serve cartographers and video game designers alike and stand as a contribution towards the integration of the two disciplines.

### 5.1.1 The Four I's of Playful Maps (Cartography to games)

RQ #1: *How do video game maps exhibit interactivity, immersiveness, incompleteness, and inclusiveness of playful maps through traditional cartographic frameworks?*

Most results in Chapter 4 supported the interactive, immersive, incomplete, and inclusive nature of playful maps in video games, outlining extant practices in contemporary video game map design and insights into how interactivity and representation in traditional cartography could contribute to playful map design practices. Overall, the maps in the sample conformed to cartographic principles, but hold potential for improvement in how these principles are leveraged to aid the playful characteristics of video game maps and overall game design.

Both primary and secondary interactivity were prevalent across the sample of video game maps, confirming the importance of interactivity as a characteristic of playful maps and supporting a distinction between the two levels of interactivity for playful maps. *Save*, *pan*, *zoom*, and *retrieve* were implemented as primary interaction in a majority of the maps, while *resymbolize*, *pan*, and *overlay* were the most prevalent secondary interactions. Direct manipulation commonly was implemented to enable interaction freedom in the map and often was accompanied by other interface styles to support interaction flexibility. Additionally, unique UI features such as YAH symbols, POIs, vantage points, and NPCs generally conformed to recommendations for designing visual affordances in cartography. Playful maps diverged from traditional cartography, however, in the lack of learning materials and exclusion of certain interaction operators (such as *import*, *export*, *reexpress*, *or calculate*), outlining opportunities for video game designers to explore to improve the interactivity of their maps and games.

Diegetic and situated immersion also commonly were supported in the sample maps, confirming immersiveness as a central characteristic of playful maps. The results showed that the type of map often determines how game designers create an immersive experience, with 90% of all games (64/71) including full-sized and/or mini-maps for diegetic and only 10% (7/71) supporting situated immersion through superimposed and/or active maps, suggesting that game designers use maps to immerse the player in gameplay rather than immersing the player within the virtual world. Additionally, the selected map type was related to the genre of the game, suggesting different types of maps are more suitable for certain gameplay than others. The use of interaction to support immersion in video game maps was sparse, with active maps, map acquisition, and natural metaphors for interaction as potential methods to improve this. Interaction operators such as *pan*, *zoom*, *retrieve, annotate*, and *overlay* were used as natural metaphors in the sample maps. These operators are commonplace in traditional interactive cartography, making them appropriate for supporting situated immersion in playful maps. Representation, however, was used to enforce both diegetic and situated immersion in the video game map, with color the most widely used dimension of the map's aesthetic style used for this purpose. Cartographic form was used to emphasize wayfinding over immersion, while typography, texture, and overall stylistic congruence could be used more frequently to better support situated immersion through the map.

Incompleteness was prevalent in the sample maps (51/71, 72%), acting as a driving force for encouraging gameplay and confirming incompleteness as a characteristic of playful maps. Completion only was afforded through secondary interaction, posing an interesting question of whether or not primary interaction could be implemented by video game designers as a tool to support incompleteness. The prevalent pairing of the interaction operator *pan* with *overlay* and *resymbolize* to complete the map appears to be a first notable interactive design convention for playful maps. The incompleteness of map features was an apparent motivator for gameplay, but incomplete YAH symbols appeared to be an underutilized pursuit to facilitate this motivation. Incompleteness by extent (33/51, 65%) and incompleteness by feature (41/51, 65%) largely conformed to cartographic principles of uncertainty by using *crispness* and *color value* as well as *texture* and *color hue*.

Inclusive playful maps only are possible through the social-communicative gameplay of multiplayer games, thus, only were present in a subset of the sample (31/71, 44%). However, the inclusive maps included in the analysis allowed for the examination of geocollaboration in playful spatiotemporal contexts. The ubiquity of playful collaboration through different-place/same-time in multiplayer games (31/31, 100%) suggests better overall immersion with player-to-player interaction, providing insight into how web-enabled maps change interpersonal experience of place. Geocollaboration often is included to support known allies working together, as well as challenge the player to explore and strategize as they encounter unknown geographies and enemies in the game, supporting situated immersion as well. The symbolization of these player-controlled characters generally adhered to cartographic principles of representation, with the correct and abundant use of visual variables like *shape* and *color hue*.

### 5.1.2 Interaction and Representation in Playful Maps (Games to cartography)

RQ #2: *How do video game maps utilize elements of interaction and representation as cartographic tools for play?*

The playful maps in the sample leveraged interaction and representation in unique ways to serve the playful nature of the game. Many of the results in Chapter 4 provided insight into how these applications could potentially inform interaction and representation design in traditional cartography.

For interaction, the distinction between primary and secondary interaction was crucial in evaluating interactivity in playful maps. Secondary interaction was more common than primary interaction in all sets of codes, calling for further research considering the distinction between the two levels of interaction for maps supporting work productivity as well as play. Regarding work, the distinction between primary and secondary interaction relates directly to the design of mobile maps, where the human user replaces the avatar in committing secondary interactions through real-world movement. When considered as a separate form of interaction, secondary interaction operators in traditional maps potentially could be more grokkable when evoked through gestures of the user, improving memorability and user satisfaction through situated immersion in the map. Secondary interactions also could aid in reducing workload during map use by replacing long sequences of primary interactions. The unique application of such primary interactions, however, could inform traditional map design as well. As seen in mini-maps, the constraint of certain primary interaction operator primitives like *pan* and *zoom* could be translated to mobile map design when wayfinding on foot or in a car and instead implementing map browsing through secondary interaction. Other interactions like *save* could be used as motivating operators to reduce stress and encourage risks when ‘playing’ with designs in traditional maps (Perkins 2009), while *edit* in playful maps may translate to traditional contexts like planning and geodesign.

Cartographic representation in playful maps yielded insights that could potentially improve traditional maps for work productivity. Considering interface styles, direct manipulation interfaces were used for a wider range of primary interaction operators than indirect menu selection. Additionally, the use of maps as linked isomorphs in playful maps might provide unique design opportunities in traditional interactive maps. The use of form, color, typography, and texture can immerse the user in the spatial and narrative context of the map, potentially improving memorability and likability. The visual variables *color hue* and *texture* were used to represent uncertainty in the map, against recommendations in traditional cartography. However, these cases may encourage cartographers to reconsider how these are used in maps for work productivity. The use of the visual variable *size* to represent categorical difference in playful maps had little impact on gameplay, suggesting that when data is limited to two categories, *size* may be effective in representing categorical differences. *Orientation* was used for nominal, ordinal, and numerical information, confirming its effectiveness for nominal data and suggesting that it may be more effective at representing ordinal and numerical data than cartographic researchers may believe. Finally, ‘ghost’ or ‘trace’ solutions representing other users across time may serve as an asset to geocollaboration in maps for work.

## 5.2 Limitations

Limitations in this research stem from the small number of sampled video games over a relatively short period of time. The inclusion of more games from each year could reveal insights from less popular, yet equally valuable, video game maps. A larger temporal window would also have revealed important trends in video game cartography, potentially providing insight into the development of the contemporary playful maps and mapping practices analyzed in this research. Finally, classification by game genre proved to be problematic in games that blended multiple types of gameplay. Game genre is reliant on several factors and is accordingly difficult to classify. A more detailed classification scheme would have been helpful in categorizing game types.

## 5.3 Future Directions

This research provides an initial look into the design of playful maps in video games, examining how traditional cartography could improve these maps (RQ #1) and how video game maps could inform design in traditional cartography (RQ #2). Findings from the first research question highlight a few potential directions for game designers to explore how to potentially improve their games through cartographic interaction and representation. Interaction operators that were completely absent in the sample maps (e.g., i*mport*, *export*, *reexpress*, *arrange*, *sequence*, *calculate*, and *search*) could be utilized in games such as strategy games to help the user parse through the large amounts of spatial data provided to the player. Additionally, the operator *edit* opens up unique design space for video game creators. Permitting the user to change the virtual world through map use could allow for intriguing and entertaining gameplay, particularly outside of the strategy games where it was observed in the sample.

The findings of the second research question offer a closer look at what it means to gamify non-playful products. Gamification, also described as gameful design, can be more than the application of a single gameful element, such as a reward system of points, badges, and achievements to encourage and increase user activity (Deterding et al. 2011). Much like a graphic designer, a gameful designer could examine all possibilities to determine which elements might best serve the purpose and end goal of the product. While this research specifically examined maps, gameful design could apply to a broad range of disciplines when thoughtfully tailored to the product.

Playful maps play a large role in the user experience (UX) of a video game. The relationship between the map type and the level of immersion it supports is a consideration that could also apply to UX design in the broader field of human-computer interaction (HCI). Designing user interfaces and experiences to facilitate both diegetic and situated immersion could lead to better likability and usability of the product. Additionally, intentional incompleteness in a product could increase user motivation and potentially create a better experience. The consideration of immersiveness and incompleteness in UX design could prove fruitful for all disciplines that draw from HCI.

Mobile maps and location-based services (LBS) relate to the interactivity in playful maps. The distinction between primary interaction through the map interface and secondary interaction through avatar/user movement suggests a re-examination of cartographic interaction through non-interface actions. The examination of secondary interaction could become increasingly important with the rising presence of ‘smart’ devices (i.e., those that can connect to other devices through networks) and location-based technology.

Along with these technological advances, devices supporting augmented reality (AR) and virtual reality (VR) are quickly becoming readily accessible to the public. Video games are one of the early adopters of such technology and could provide deeper insight into a player’s immersion into the game. The examination of how players interact with the maps and navigate through virtual world of the game could inform real-world applications of AR and VR.

Geocollaboration also stands to gain from the inclusive nature of playful maps. Social collaboration and competition in the sample video games provided insights into how to represent other human users across space and time. With the ever-improving network and graphical capabilities of computing devices, an examination into how playful inclusiveness, such as the ‘ghost’ tracing from *Mario Kart 8*, could inform how people collaborate across space and time to achieve goals in work contexts.

The tasteful inclusion of interactive, immersive, incomplete, and inclusive elements in these examples could allow the user to feel invested in the product and effectively fulfill the purpose of it. Just as in the sample, these principles are not required in tandem or in equal amounts for a successful gamified product. Any of the four characteristics of playful maps could be applied to the examples above, with or without each other. Other playful characteristics and principles could exist that were not examined in this research and may be manipulated to benefit non-playful contexts as well.

Finally, to find more about playful maps themselves, user studies with playful maps or the integration of playful maps in geography education would be useful to gauge how well different aspects of cartographic design support the interactive, immersive, incomplete, and inclusive nature of playful maps. While this research examined the *product* of playful map design, an interview study with video game designers could provide insight into the *process* of playful mapmaking outside of traditional cartography. Additionally, the examination of non-digital game maps (such as board games) may reveal unique insights considering the interactive, immersive, incomplete, and inclusive nature of playful maps.

Overall, the sampled video games provided an elucidating perspective on how playful maps conform to and diverge from traditional cartography. This researched highlighted opportunities where video game designers could improve their maps to enforce interactivity, immersiveness, incompleteness, and inclusiveness in their games according to cartographic principles, as well as where cartographers could investigate how the characteristics of playful maps might affect the way they think about interaction and representation. In the end, the relationship between games and space is strong and further examination into the overlap of the two could continue to improve each discipline. However, the implications of gameful design go well beyond cartography and hold potential to improve several industries and fields of study.

# Appendix A – List of games included in the study

| Games | Developer |
|---|---|
| 2016 | |
| Titanfall 2 | Respawn Entertainment |
| Stardew Valley | Sickhead Games |
| Battlefield 1 | EA DICE |
| Dishonored 2 | Arkane Studios |
| XCOM 2 | Firaxis Games |
| Sid Meier's Sid Meier’s Civilization VI | Firaxis Games |
| DOOM | id Software |
| Pokemon Sun | Game Freak |
| Total War: WARHAMMER | Creative Assembly |
| Firewatch | Campo Santo |
| 2015 | |
| The Witcher 3: Wild Hunt | CD Projekt RED |
| Pillars of Eternity | Obsidian Entertainment |
| Fallout 4 | Bethesda |
| Batman: Arkham Knight | Rocksteady Studios |
| Monster Hunter 4 Ultimate | Capcom |
| Rise of the Tomb Raider | Crystal Dynamics |
| Heroes of the Storm | Blizzard Entertainment |
| Halo 5: Guardians | 343 Industries |
| Axiom Verge | Thomas Happ Games LLC |
| Xenoblade Chronicles X | Monolith Soft |
| 2014 | |
| Dragon Age: Inquisition | BioWare |
| Middle-earth: Shadow of Mordor | Monolith Productions |
| Year Walk | Simogo |
| Divinity: Original Sin | Larian Studios |
| Titanfall | Respawn Entertainment |
| Bravely Default | Silicon Studio |
| Mario Kart 8 | Nintendo |
| Far Cry 4 | Ubisoft |
| Child of Light | Ubisoft |
| Ultimate General: Gettysburg | Game-Labs |
| 2013 | |
| Grand Theft Auto V | Rockstar Games |
| The Legend of Zelda: A Link Between Worlds | Nintendo |
| Dota 2 | Valve Corporation |
| Assassin's Creed IV: Black Flag | Ubisoft |
| Pokemon Y | Game Freak |
| Animal Crossing: New Leaf | Nintendo |
| The Swapper | Facepalm Games |
| Tomb Raider | Crystal Dynamics |
| Europa Universalis IV | Paradox Development Studio |
| Path of Exile | Grinding Gear Games |
| 2012 | |
| Mass Effect 3 | BioWare |
| Xenoblade Chronicles | Monolith Soft |
| Dishonored | Arkane Studios |
| Borderlands 2 | Gearbox Software |
| Far Cry 3 | Ubisoft |
| XCOM: Enemy Unknown | Firaxis Games |
| Fez | Phil Fish |
| Torchlight II | Runic Games |
| Assassin’s Creed III | Ubisoft |
| Halo 4 | 343 Industries |

# Appendix B – Codes used in the QCA

| Code | Definition |
|---|---|
| **Interaction** | |
| Levels of Interaction | |
| 1_pan | change the geographic center of the map through primary interaction |
| 1_pan_style | interface style used to pan |
| 1_zoom | change the scale of the map through primary interaction |
| 1_zoom_style | interface style used to zoom |
| 1_annotate | add graphic markings and/or textual notes to map through primary interaction |
| 1_annotate_style | interface style used to annotate |
| 1_resymbolize | change design parameters of map features through primary interaction |
| 1_resymbolize_style | interface style used to resymbolize |
| 1_overlay | adjust (i.e., toggle visibility) of map features through primary interaction |
| 1_overlay_style | interface style used to overlay |
| 1_filter | identify map features meeting certain criteria through primary interaction |
| 1_filter_style | interface style used to filter |
| 1_retrieve | request specific details about map features through primary interaction |
| 1_retrieve_style | interface style used to retrieve |
| 1_save | store the geographic information of map through primary interaction |
| 1_save_style | interface style used to save |
| 1_edit | manipulate geographic information underyling the map through primary interaction |
| 1_edit_style | interface style used to edit |
| 1_import | load geographic information or previously generated map through primary interaction |
| 1_import_style | interface style used to import |
| 1_export | extract geographic information or generated map through primary interaction |
| 1_export_style | interface style used to export |
| 1_calculate | derive new information about map features of interest through primary interaction |
| 1_calculate_style | interface style used to calculate |
| 1_search | identify a particular location or map feature of interest through primary interaction |
| 1_search_style | interface style used to search |
| 1_reexpress | change the visual cartographic isomorph through primary interaction |
| 1_reexpress_style | interface style used to reexpress |
| 1_arrange | manipulate the layout of views through primary interaction |
| 1_arrange_style | interface style used to arrange |
| 1_sequence | generate an ordered set of maps through primary interaction |
| 1_sequence_style | interface style used to sequence |
| 1_rotate | change the orientation of the map through primary interaction |
| 1_rotate_style | interface style used to rotate |
| 1_reproject | change the map projection through primary interaction |
| 1_reproject_style | interface style used to reproject |
| 2_pan | change the geographic center of the map through secondary interaction |
| 2_zoom | change the scale of the map through secondary interaction |

| | |
|---|---|
| 2_annotate | add graphic markings and/or textual notes to map through secondary interaction |
| 2_resymbolize | change design parameters of map features through secondary interaction |
| 2_overlay | adjust (i.e., toggle visibility) of map features through secondary interaction |
| 2_filter | identify map features meeting certain criteria through secondary interaction |
| 2_retrieve | request specific details about map features through secondary interaction |
| 2_save | store the geographic information of map through secondary interaction |
| 2_edit | manipulate geographic information underyling the map through secondary interaction |
| 2_import | load geographic information or previously generated map through secondary interaction |
| 2_export | extract geographic information or generated map through secondary interaction |
| 2_calculate | derive new information about map features of interest through secondary interaction |
| 2_search | identify a particular location or map feature of interest through secondary interaction |
| 2_reexpress | change the visual cartographic isomorph through secondary interaction |
| 2_arrange | manipulate the layout of views through secondary interaction |
| 2_sequence | generate an ordered set of maps through secondary interaction |
| 2_rotate | change the orientation of the map through secondary interaction |
| 2_reproject | change the map projection through secondary interaction |
| Representing Interaction | |
| direct_map_feature | pointing device used to manipulate features in map |
| direct_entire_map | pointing device used to manipulate the map as a whole |
| direct_widget | pointing device used to manipulate a widget affecting the map |
| direct_linked_isomorph | pointing device used to manipulate the map through another visualization |
| direct_map_legend | pointing device used to manipulate the legend as an interface widget |
| menu_selection | select one or several items from presented list |
| avatar | avatar used to commit interactions with map features |
| YAH | you-are-here symbol present in the map |
| YAH_vizvar | visual variables used to represent the YAH symbol |
| VP | vantage points present in the map |
| VP_vizvar | visual variables used to represent vantage points |
| POI | points of interest present in the map |
| POI_vizvar | visual variables used to represent points of interest |
| NPC | non-player characters present in the map |
| NPC_vizvar | visual variables used to represent non-player characters |
| learning | presence/absence of learning materials in the game |
| learning_type | type of learning material provided |
| learning_context | if the learning material is provided through in-game dialogue or as a UI element |
| **Immersion** | |
| Interactive Immersion | |
| full_sized | full-sized map |
| mini | mini-map |
| superimposed | superimposed map |
| active | active map |
| artifact | map is acquired through gameplay |
| natural_interaction | interaction with the map is metaphoric to how the avatar might interact with it |

| | |
|---|---|
| natural_operators | operators involved in natural metaphor interaction |
| interaction_level | the level of interaction for natural metaphor |
| Representing Immersion | |
| form_detailed | linework shows more geographic information |
| form_simplified | linework is generalized |
| form_accurate | linework is accurate |
| form_relative | linework is not geographically accurate, but accuracy is maintained in relative position |
| form_none | no linework for background features |
| type_presence/absence | presence/absence of labels on map |
| color_bold | background color is bold and with great contrast |
| color_muted | background color is muted with minimal contrast |
| color_dark | background color is dark |
| texture_presence/absence | presence/absence of texture used to reference certain medium |
| stylistic | map graphically appears as the user would expect within the virtual world |
| **Incomplete** | |
| Interactive Incompleteness | |
| 1_pan | panning through primary interaction completes geographic information in the map |
| 1_zoom | zooming through primary interaction completes geographic information in the map |
| 1_annotate | annotating through primary interaction completes geographic information in the map |
| 1_resymbolize | resymbolizing through primary interaction completes geographic information in the map |
| 1_overlay | overlaying through primary interaction completes geographic information in the map |
| 1_filter | filtering through primary interaction completes geographic information in the map |
| 1_retrieve | retrieving through primary interaction completes geographic information in the map |
| 1_save | saving through primary interaction completes geographic information in the map |
| 1_edit | editing through primary interaction completes geographic information in the map |
| 1_import | importing through primary interaction completes geographic information in the map |
| 1_export | exporting through primary interaction completes geographic information in the map |
| 1_calculate | calculating through primary interaction completes geographic information in the map |
| 1_search | searching through primary interaction completes geographic information in the map |
| 1_reexpress | reexpressing through primary interaction completes geographic information in the map |
| 1_arrange | arranging through primary interaction completes geographic information in the map |
| 1_sequence | sequencing through primary interaction completes geographic information in the map |
| 1_rotate | rotating through primary interaction completes geographic information in the map |
| 1_reproject | reprojecting through primary interaction completes geographic information in the map |
| 2_pan | panning through secondary interaction completes geographic information in the map |
| 2_zoom | zooming through secondary interaction completes geographic information in the map |
| 2_annotate | annotating through secondary interaction completes geographic information in the map |
| 2_resymbolize | resymbolizing through secondary interaction completes geographic information in the map |
| 2_overlay | overlaying through secondary interaction completes geographic information in the map |
| 2_filter | filtering through secondary interaction completes geographic information in the map |
| 2_retrieve | retrieving through secondary interaction completes geographic information in the map |
| 2_save | saving through secondary interaction completes geographic information in the map |
| 2_edit | editing through secondary interaction completes geographic information in the map |

| | |
|---|---|
| 2_import | importing through secondary interaction completes geographic information in the map |
| 2_export | exporting through secondary interaction completes geographic information in the map |
| 2_calculate | calculating through secondary interaction completes geographic information in the map |
| 2_search | searching through secondary interaction completes geographic information in the map |
| 2_reexpress | reexpressing through secondary interaction completes geographic information in the map |
| 2_arrange | arranging through secondary interaction completes geographic information in the map |
| 2_sequence | sequencing through secondary interaction completes geographic information in the map |
| 2_rotate | rotating through secondary interaction completes geographic information in the map |
| 2_reproject | reprojecting through secondary interaction completes geographic information in the map |
| Representing Incompleteness | |
| YAH_incomplete | you-are here symbol is initially incomplete and can become complete |
| YAH_inc_method | method through which the you-are-here symbol becomes complete (vantage point or symbol discovery) |
| VP_incomplete | vantage points are initially incomplete and can becom complete |
| VP_inc_method | method through which vantage points become complete (vantage point or symbol discovery) |
| POI_incomplete | points of interest are initially incomplete and can become complete |
| POI_inc_method | method through which points of interest become complete (vantage point or symbol discovery) |
| NPC_incomplete | NPC locations are initially incomplete and can become complete |
| NPC_inc_method | method through which NPC locations become complete (vantage point or symbol discovery) |
| boundary | presence/absence of fuzzy boundaries |
| boundary_inc_method | method through which geographic information becomes complete |
| boundary_vizvar | visual variables used to distinguish discoverable areas |
| **Inclusive** | |
| Interactive inclusiveness | |
| singleplayer | presence/absence of singleplayer gameplay |
| multiplayer | presence/absence of multiplayer gameplay |
| sp_st | collaboration that occurs at the same geographic location and at the same time |
| sp_dt | collaboration that occurs at the same geographic location and at different times |
| dp_st | collaboration that occurs at different geographic locations and at the same time |
| dp_dt | collaboration that occurs at different geographic locations and at different times |
| collab_prim | collaboration occurs through primary interaction |
| collab_sec | collaboration occurs through secondary interaction |
| interactive_complete | inclusive map features become complete through interaction |
| Representing inclusiveness | |
| pc_ally | presence/absence of player-controlled allies |
| ally_vizvar | visual variables used to represent allies |
| pc_enemy | presence/absence of player-controlled enemies |
| enemy_vizvar | visual variables used to represent enemies |
| npc | presence/absence of non-player characters during multiplayer gameplay |
| npc_vizvar | visual variables used to represent non-player characters in multiplayer gameplay |

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*The Legend of Zelda: Link's Awakening* (Nintendo 1993)

*The Legend of Zelda: Ocarina of Time* (1998)

*The Legend of Zelda: Breath of the Wild* (2017)

*Assassin's Creed III* (Ubisoft 2012)

*The Elder Scrolls V: Skyrim* (Bethesda 2011)

*Assassin's Creed II* (Ubisoft 2009)

*Middle-Earth: Shadow of Mordor* (Monolith Production 2014)

*Fallout 3* (Bethesda 2008)

*Far Cry 2* (Ubisoft 2008)

*Sid Meier's Civilization V* (Firaxis Games 2010)

*Minecraft* (Mojang 2009)

*The Legend of Zelda: Wind Waker* (Nintendo 2003)

*Grand Theft Auto IV* (Rockstar Games 2008)

*The Elder Scrolls IV: Oblivion* (Bethesda 2008)

*Hollow Knight* (Team Cherry 2017)

*Halo 3* (Bungie 2007)

*Call of Duty: WWII* (Sledgehammer Games 2017)

*Fortnite: Battle Royale* (Epic Games 2017)

*Halo: Reach* (Bungie 2010)

*Halo 4* (343 Industries 2012)

*Child of Light* (Ubisoft 2014)

*Sid Meier's Civilization VI* (Firaxis Games 2016)

*Dota 2* (Valve Corporation 2013)

*Europa Universalis IV* (Paradox Development Studio 2013)

*Batman: Arkham Knight* (Rocksteady Studios 2015)

*Dishonored 2* (Arkane Studios 2016)

*Pokémon Y* (Game Freak 2013)

*Ultimate General: Gettysburg* (Game-Labs 2014)

*Firewatch* (Campo Santo 2016)

*Fallout 4* (Bethesda 2015)

*The Swapper* (Facepalm Games 2013)

*The Witcher III: Wild Hunt* (CD Projekt RED 2015)

*Titanfall 2* (Respawn Entertainment 2016)

*Borderlands 2* (Gearbox Software 2012)

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