Exploration through video games

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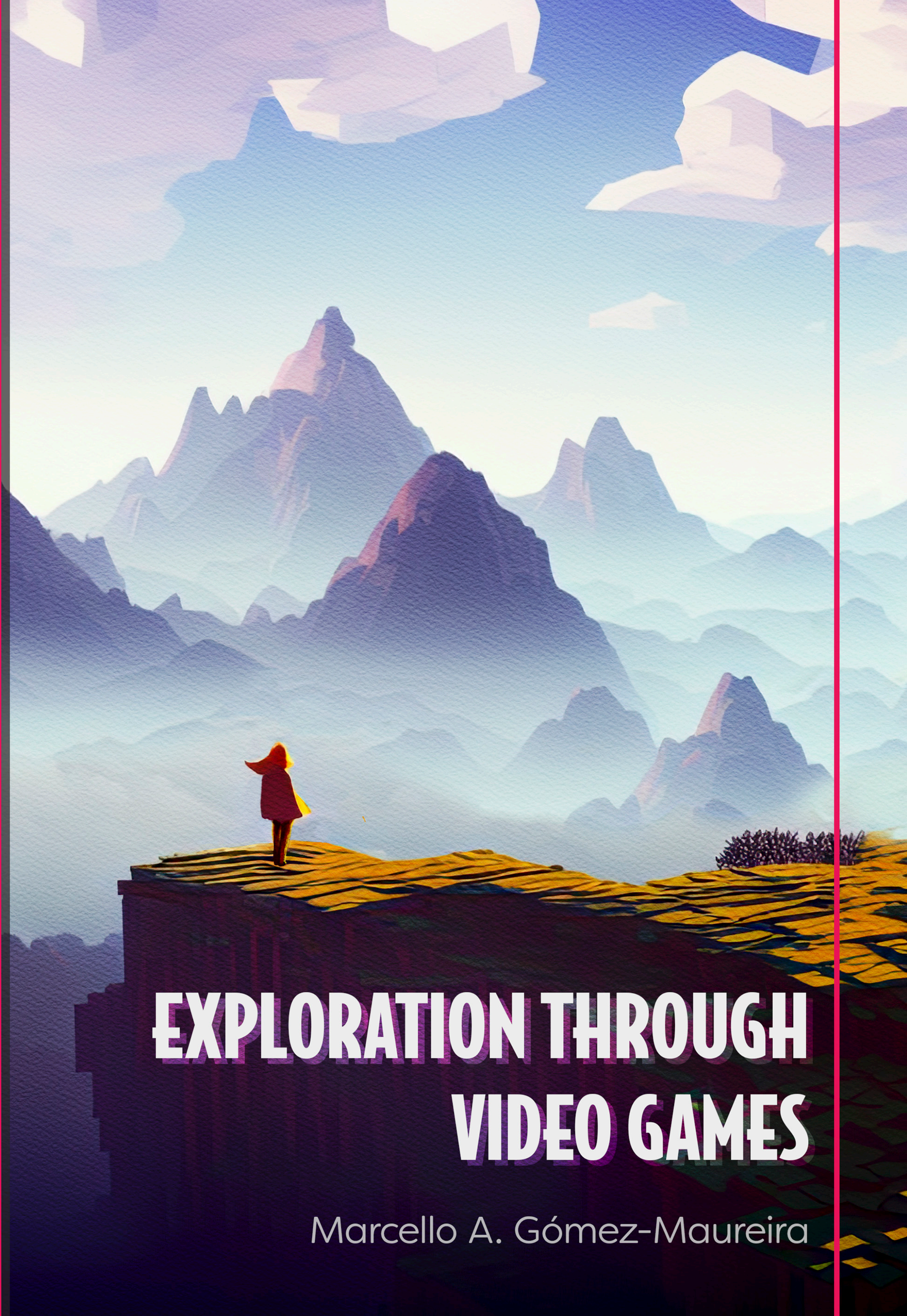

EXPLORATION THROUGH VIDEO GAMES

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Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op woensdag 26 april 2023
klokke 15:00 uur

door

Marcello Andres Gómez Maureira
geboren te Wenen, Oostenrijk
in 1984

Promotores:
Prof.dr. A. Plaat
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Promotiecommissie:
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Dedicated to my life partner and fellow unicorn
Isabelle Kniestedt

About the Author

Marcello ("Maro") A. Gómez Maureira is an interactive media researcher and designer drawn to projects involving crossdisciplinary challenges and creative exploration possibilities. He is fascinated by the potential of technologically facilitated creation and playful interactions while remaining invested in questions about the impact of technology on life and society.

Marcello was born in 1984 in Vienna, Austria. He completed an Engineering Diploma in Mechatronics (2006) at the Federal Technical College of Engineering in Mödling (Austria), a Bachelor of Engineering in Game Architecture and Design (2013) at Breda University of Applied Sciences (The Netherlands), and a Master of Science at Leiden University (The Netherlands). He completed these diplomas with the Cum Laude distinction and published his Bachelor's and Master's theses at international peer-reviewed conferences. As of the beginning of 2023, Marcello has 31 internationally peer-reviewed publications, developed four highly rated University courses at Bachelor and Master levels, and supervised 16 Master students. He has successfully acquired scholarships, seed investments, and academic funding throughout his career. In addition to his academic career, he has worked as a commercial game designer and developer, and continues to pursue creative projects through his company "Dandy Unicorns".

Summary

This thesis manuscript presents research on curiosity-driven exploration in video games and the use of video games to facilitate research and education as tools for conceptual exploration. The main research question throughout the work is: *How do video games facilitate exploration?*

The question is investigated from different perspectives across nine chapters that range from elaborating on existing work and defining involved concepts and terminology (Chapter 2), to empirical research studies (Chapters 3-7). These studies include user surveys, the iterative design of video game artifacts, and user studies of the created artifacts. The penultimate chapter outlines the increasingly common practice of using games as research tools (Chapter 8).

Chapter 3 poses the research question of *How can a video game facilitate conceptual exploration?* In an effort to answer the question through design practice, the chapter describes the creation of *CURIO*, a video game developed for classroom use that requires its players to ask critical and original questions about topics that can be defined by a teacher. The study revealed the need to highlight information gaps to stimulate curiosity for conceptual exploration. It further formed the basis for a subsequent investigation of game types.

Chapter 4 investigates the question: *What types of video games elicit exploration?* A survey of video game players was conducted to answer this question. The result was that games that balance uncertainty and structure were more likely to elicit curiosity to explore.

In Chapter 5, the survey results are used to formulate a hypothesis for the question: *What design patterns can be hypothesized for video games that elicit exploration?* Three

types of curiosity-based exploration are examined in detail: conceptual, social, and spatial exploration.

Chapters 6 and 7 pose two related research questions: *How can design patterns for exploration be implemented for validation?* and *How do design patterns for exploration influence player behavior and experience?* The research game *Shinobi Valley* was created and tested through an initial user study. The subsequent study discussed in Chapter 7 presented evidence that hypothesized design patterns effectively elicit exploratory behavior.

Chapter 8 raises the question: *How are video games used as tools for academic exploration?* It provides an overview of video games used in research efforts and reflects on using *CURIO* and *Shinobi Valley* as research tools.

In the final chapter, the manuscript concludes by summarizing the insights of the individual chapters, outlining the research contributions, and providing directions for future research.

Samenvatting

Dit proefschrift presenteert onderzoek naar nieuwsgierigheids-gedreven verkenning in videospellen en het gebruik van videospellen als hulpmiddel voor conceptuele verkenning in onderzoek en onderwijs. De hoofd onderzoeksvraag van het werk is: *Hoe faciliteren videospellen verkenning?*

De vraag wordt vanuit verschillende perspectieven onderzocht in negen hoofdstukken, variërend van het uitbreiden van bestaand werk en het definiëren van betrokken concepten en terminologie (Hoofdstuk 2), tot empirisch onderzoek (Hoofdstukken 3-7). Dit onderzoek omvat gebruikersenquêtes, iteratief ontwerp van videospellen, en gebruikersstudies met de gecreëerde spellen. Het op een na laatste hoofdstuk is gewijd aan het in kaart brengen van de steeds gebruikelijker wordende praktijk van het gebruik van spellen als hulpmiddelen in onderzoek (Hoofdstuk 8).

Hoofdstuk 3 stelt de onderzoeksvraag: *Hoe kan een videospel conceptuele verkenning faciliteren?* In een poging de vraag te beantwoorden via ontwerpwerk, beschrijft het hoofdstuk de ontwikkeling van *CURIO*, een videospel ontwikkeld voor gebruik in de klas dat zijn spelers dwingt kritische en originele vragen te stellen over onderwerpen die door een leraar kunnen worden gedefinieerd. Het onderzoek toonde aan dat het benadrukken van het verschil tussen wat een persoon al wel en nog niet weet nodig is om nieuwsgierigheid voor conceptuele verkenning te stimuleren. Het vormde ook de basis voor een vervolgonderzoek naar soorten spellen en hoe zij verkenning faciliteren.

Hoofdstuk 4 onderzoekt de vraag: *Welke soorten videospellen nodigen uit tot verkenning?* Een enquête onder videospelers werd uitgevoerd om deze vraag te beantwoorden. Het resultaat liet zien dat spellen die een balans vinden tussen onzekerheid en structuur eerder nieuwsgierigheid om te verkennen opwekken.

In Hoofdstuk 5 worden de resultaten van de enquête gebruikt om een hypothese te formuleren voor de vraag: *Welke ontwerppatronen kunnen worden verondersteld voor videospellen die verkenning oproepen?* Drie soorten nieuwsgierigheids-gedreven verkenning worden in detail onderzocht: conceptuele, sociale en ruimtelijke verkenning.

Hoofdstukken 6 en 7 stellen twee gerelateerde onderzoeksvragen: *Hoe kunnen ontwerppatronen voor verkenning worden geïmplementeerd voor validatie?* en *Hoe beïnvloeden ontwerppatronen voor verkenning het gedrag en de ervaring van spelers?* Het onderzoeksspel *Shinobi Valley* werd gemaakt en getest via een eerste gebruikersstudie. De daaropvolgende empirische studie die in Hoofdstuk 7 wordt besproken, toonde aan dat de veronderstelde ontwerppatronen effectief waren bij het opwekken van verkennend gedrag.

Hoofdstuk 8 stelt de vraag: *Hoe worden video games gebruikt als hulpmiddel voor wetenschappelijke verkenning?* Het biedt een overzicht van videospellen die zijn gebruikt als onderdeel van onderzoeksinspanningen en reflecteert op het gebruik van *CURIO* en *Shinobi Valley* als onderzoekshulpmiddelen.

Tot slot concludeert het manuscript met een samenvatting van de de inzichten uit de individuele hoofdstukken, het benoemen van de bijdragen aan het onderzoeksveld, en het bieden van richtingen voor toekomstig onderzoek.

Contents

1 Introduction

Video games have long matured past their origins of a niche interest enjoyed by a few in the seclusion of their private homes. Now, those who enjoyed early generations of video games as children have grown up and become the creators of new media themselves. Though not without growing pains, the result is that video games have manifested themselves as a global industry and cemented their position within popular culture. Names like *Minecraft* (Mojang 2011) and *Fortnite* (Epic Games 2017) are widely recognized, even by the uninitiated, and major industries have partnered with game developers to create, e.g., *Horizon Zero Dawn* (Guerilla Games 2017) *Lego*, or used video games as inspiration, e.g., the movie *Free Guy*, to make products appealing to a wide audience.

Players enjoy video games for a wide variety of reasons (Bateman 2016). In *Reality is Broken*, designer Jane McGonigal (2011) suggests that players of video games flock to them because they provide them something that the real world does not. Some may empower the player to strategize, plan, and make decisions (Tondello and Nacke 2019; Yee 2015). Others allow them to affect storylines and characters, deciding not only their own destiny, but that of entire worlds as well (Fortes Tondello et al. 2018). Some offer a safe space to encounter the unknown, enabling players to experience scenarios and environments they would otherwise be unlikely to be exposed to (Kivikangas et al. 2011). They also connect players across the globe, stimulating both competition and collaboration, and positively affecting social well-being (Raith et al. 2021). Video games, that is, games that mediate play through electronic displays (simplified on the basis of Tavinor 2008), inherit much of their engaging properties from what can be said about games in general. Any professional chess player can likely attest to a physical game's ability to empower players to strategize and plan.

This thesis focuses specifically on video games. However, throughout the thesis, the term "game" is used to refer to "video games" for the sake of brevity.

What distinguishes video games from their non-digital form is that they involve non-human computation and thus are intimately linked to the rapid growth of computing devices. Advances in computer science lead to more capable computing devices, which in turn allows video games to involve increasingly complex interactive scenarios. With the involvement of the Internet, video games further allow for play between players all over the world, offering a virtual "third place"; a place outside of home or work for meeting other people (Steinkuehler and Williams 2006; Moritzen 2022).

To some, video games can offer a space to explore; the self, one's relationships with others, or the world at large. At the start of the Covid-19 pandemic, millions of people enjoyed the calm getaway provided by *Animal Crossing: New Horizons* (Nintendo EPD 2020) in which they own and design their home on an idyllic island where no housing crisis exists (Russell 2022). LGBTQ+ players of *The Sims 4* (Maxis 2014) rejoice at the addition of customization features that allow them to create themselves as virtual people and play out their stories (Rowe 2022). With our own planet seemingly mapped out beyond what can be discovered by an individual, virtual worlds like the ones from *The Legend of Zelda: Breath of the Wild* (Nintendo EPD 2017) and *Elden Ring* (FromSoftware 2022) serve as the new frontier.

The core concept investigated in this thesis is that of *exploration* that is the result of curiosity (Grossnickle 2016). In this work, curiosity is understood as an intrinsic motivation for pursuing new knowledge or experiences, and often accompanied by positive emotions such as pleasure and excitement. Thus, intrinsically motivated exploration is understood as the behavior that results from curiosity. Based on the video game examples above, it can be observed that exploration in and through games is not a single phenomenon. Some forms are both the immediate goal in and direct result of game design efforts. Examples include the discovery of virtual environments, the solving of puzzles, or the seeking out of secrets, characters and storylines. Others emerge through the player's interaction with the game systems, for example, in the case of the aforementioned experimentation with LGBTQ+ experiences in *The Sims* (Krobová, Moravec, and Švelch 2015). While such explorations cannot be guaranteed and do not necessarily occur for every player, they are the result of deliberate design decisions, made to make these and other forms of exploration more likely.

Such design efforts can be seen, not only in entertainment games, but also in games with purposes other than entertainment (often referred to as applied games or serious games, further described in Chapter 2). Games have been used to present players with virtual scenarios so that they can safely learn real-world behavior and experience the consequences of their decisions; e.g., evacuation strategies (Silva et al. 2013), firefighting (Williams-Bell et al. 2015), or social interactions (Ke and Moon 2018). They have even been used to engage in philosophical topics, such as considering questions like "What is soup?" (Gualeni 2018). One challenge in such projects is to assess whether conceptual exploration has indeed taken place, as well as form design guidelines in understanding how design decisions can enable and elicit it.

It follows that, in addition to games facilitating exploratory behavior in the player, they can be used as vehicles for the exploration of larger academic questions. In this context, games are used to investigate, as well as generate and disseminate knowledge. Hence, exploration in (applied) games, and academia in particular, is a complex and multifaceted topic that comes into play at multiple levels of the development and research process.

The topic of this thesis is thus the broad understanding of *exploration through games*, with a particular focus on games applied in academic pursuits. While ample literature exists on game design, exploration is but a sub-topic that has seen limited dedicated study. The aim of this thesis is to address that gap through the discussion of three distinct though interrelated research efforts:

1. A design case study of a video game made for classrooms, purposefully created to elicit conceptual exploration.
2. An examination of players' experience with different forms of exploration and how they are elicited by different types of games. Based on this work, design patterns for different forms of exploration are formulated.
3. A subset of these design patterns (focused on spatial exploration) is incorporated into a game for research, and subsequently used in an empirical study.

Together, these studies provide insight into exploration by players, as well as, on a higher level of abstraction, the practice of using games for research purposes. The resulting work is an investigation of exploration in and through games of different forms within research projects, which informs and inspires both research on exploration within the fields of game studies and game design, and the use of games in academic research projects in general.

1.1 Key Concepts and Research Objectives

Exploration, as previously stated, is the expression of curiosity — two key concepts underlying this work that will be explored in Chapter 2. As will be discussed, it is possible to be curious without showing exploratory behavior. A key distinction made in the study of curiosity is between *state* curiosity (i.e., being curious, or having the drive to explore) and *trait* curiosity (i.e., a person's disposition to becoming curious), with trait curiosity having been shown to influence state curiosity (Kashdan and Roberts 2004).

Games have been posited as a suitable medium to study curiosity (To et al. 2016), as they involve many related concepts that can help to understand how and why people become curious. Due to their interactive nature, they are furthermore capable of eliciting exploratory behavior in a controlled environment, and allow for that behavior to be recorded for study (Jirout and Klahr 2012).

As also discussed in Chapter 2, no single formally accepted definition of what constitutes a *game* exists. In the context of this work, games are considered intentionally bounded systems, designed to facilitate cognitively or affectively engaging scenarios through interaction. Additionally, it is not a requirement for a game to be *fun*, as is often associated with them as a medium. Rather, this work takes the position that games are complex systems that can give rise to a number of emotional and behavioral states (Karpouzis and Yannakakis 2016), with the end goal of resulting in a satisfying experience (Stenros 2017). In doing so, the working definition also allows for the inclusion of applied or serious games (Schmidt, Emmerich, and Schmidt 2015), further defined in Chapter 2.

The empirical work presented in this thesis, described in Chapters 3, 4, 6 and 7, examines exploration in and through games in its various forms. Building upon this work, Chapter 8 takes up the broader discussion of using games for academic research. Together, these chapters thus form a comprehensive overview of each of the factors that come into play when applying games in an academic setting. In taking this broad perspective, it is the intention of this thesis to provide a basis for a professionalization of exploration through games in academic environments. This can help those who come from different fields with an interest in using games in their academic practice, as well as those already more familiar with using games in this context with insights into the more in-depth analysis that is necessary when designing and deploying games for this purpose.

1.2 Research Approach

The study of video games is relatively new compared to other academic fields. This has resulted in a multidisciplinary research practice that is based on a range of theory and methods brought in by academics from their own fields (G. S. F. Mäyrä 2008). Games are also a complex media form in which a variety of practices, including art, design, and technology come together to form a unique and emotional player experience (Newman 2002). Because of this, games also require an interdisciplinary approach in order to properly assess and understand them. For most research questions related to video games, it is not sufficient to analyze a game as a technical construct without consideration for the emotional experience that results from interacting with it, in the same way that studying players without considering technical or design aspects does not suffice (G. S. F. Mäyrä 2008).

Game User Research (GUR) describes a field of study, predominantly pursued within the entertainment game industry that has also gained a foothold in academic practice. It is integral to commercial game development in understanding players, and how to design, build, and launch successful games (Desurvire and El-Nasr 2013). Inherent to GUR is a multimodal approach to measuring and assessing user experience. This happens throughout development in iterative cycles, utilizing a combination of qualitative and quantitative research methods (e.g., focus groups, surveys, and interviews, but also the logging of player behavior through metrics, eye tracking, and assessing experience through biometric measures). Empirical work discussed in Chapter 3, 4, 6, 7 of this thesis follows GUR principles and methods integrated in a research through design approach (Zimmerman, Forlizzi, and Evenson 2007), in which new knowledge is generated through iterative cycles of design practice.

1.3 Research Questions and Chapter Outline

The main research question explored by this thesis is:

> **Main Research Question**
> How do games facilitate exploration?

The work is structured into nine chapters, of which the current introduction is the first. Chapter 2 presents an overview of the theoretical concepts underlying this research. It includes a working definition of games for the purposes of the research, as well as a literature review on their uses for non-entertainment purposes, in particular those purposes related to curiosity (i.e., game-based learning). The foundational research on curiosity and the resulting behavior of exploration is furthermore discussed, as well as how it has been used in the study of games. The chapter identifies opportunities for further study, which form the basis and scope for the rest of the work.

Following this, the thesis addresses the following sub-questions:

> **Sub-Question 1**
> How can a game facilitate conceptual exploration?

A common goal in using applied games is to induce conceptual exploration of a non-entertainment topic. Based on the existing understanding of conceptual exploration, Chapter 3 presents a design case study that examines how a game can be used to facilitate conceptual exploration, encouraging curiosity for the exploration of a non-entertainment topic. While other games have been developed that share this purpose, different cases utilize different design approaches, and validation studies show differing results in terms of effectiveness (De Freitas 2018). The chapter describes how exploration is elicited through design, and results in desired player behavior (i.e., exploration). In doing so, the study brings to light, in a most transparent manner, how game design decisions can be used to elicit conceptual exploration in players. Additionally, it shows how even aiming to elicit a single type of curiosity is a complex task, motivating a broader investigation into different types of curiosity and how they are elicited through game design.

Sub-Question 2
What types of games elicit exploration?

Branching out from a singular case in which the process of eliciting conceptual exploration is exemplified, the thesis next considers how exploration may be elicited across a wide variety of games, and brings in the perspective of players to determine what types of games are best at eliciting various types of exploration. Chapter 4 describes an exploratory, quantitative study that examines successful commercial entertainment games and the types of exploration they elicit in players. The study is based on the 5-dimensional curiosity questionnaire (Kashdan et al. 2018), and uses its five dimensions of curiosity to form a selection of games that fit each dimension. Players furthermore offer their own suggestions for titles that invoked certain types of exploration. In doing so, this chapter provides the first research contribution in the form of a selection of games that should be considered for further study in curiosity and the accompanying forms of exploration.

Sub-Question 3
What design patterns can be hypothesized for games that elicit exploration?

Out of the corpus of games produced in Chapter 4, the game genres that were considered most capable of eliciting exploration by players are studied in more detail. Based upon these findings, Chapter 5 shows the formulation of hypothetical design patterns for different types of exploration, which form the basis for the chapters that follow.

Sub-Question 4
How can design patterns for exploration be implemented and evaluated for empirical study?

Following the formulation of design patterns, Chapter 6 describes how such design patterns can be used in practice. Using the previously formulated patterns for spatial exploration as an example, they are subsequently implemented in a game to study whether they succeed in inducing exploratory behavior.

Sub-Question 5
How do design patterns for exploration influence player behavior and experience?

Further building upon the case outlined in the previous chapter, Chapter 7 then presents the empirical study of the design patterns for exploration, discussing considerations in using the game as an experiment stimulus in an empirical study and describing the methodology and process in conducting such a study. It describes factors to be considered in using games to measure player behavior and experience, and how those influence the design of quantitative studies. It also shows that, while the design patterns indeed affect player behavior and experience, there are other factors (e.g., the presence of in-game goals or monetary compensation for study participation) involved in exploratory behavior as well that should be considered when similar topics are studied in detail. Together, Chapters 6 and 7 provide a practical example on how the empirical study of exploration in games can take place, forming a foundation for future research in this area.

Sub-Question 6
How can games be used as tools for academic exploration?

After the closer examination of exploration from the perspective of a designer creating an experience for the player, the thesis concludes by expanding the view of exploration through games by examining their use within academia. Chapter 8 examines the games created as part of the studies presented in Chapters 3, 6 and 7 and uses them, in combination with a review of relevant literature, in order to map the use of games for academic exploration — i.e., the generation, evaluation, or dissemination of knowledge. This chapter takes a meta-perspective on the work discussed in prior chapters, moving away from the games' direct goals of inducing exploration in players, and instead taking the view of the academic stakeholder, who uses these games as tools in their exploration of a larger topic. As such, this chapter maps the various uses of games for exploration and identifies important facets in their use and design, to serve as a basis for further discussion and research efforts.

Finally, Chapter 9 summarizes the findings of the research by revisiting the research questions. It answers the main research question by providing a foundation for research on exploration through games on three levels. First, it exemplifies how games can facilitate conceptual exploration. Second, it provides insight into how such games may be designed and studied through the use of design patterns. Third, it covers the level of academic exploration, where games are used as tools to explore and generate knowledge. By combining these different perspectives on exploration through games, the thesis forms a solid foundation for various types of future studies with games on exploration and related topics. The thesis concludes by highlighting the contributions of the work.

1.4 Underlying Publications

Parts of this dissertation are based on peer-reviewed publications. The list below shows an overview of these publications (ordered by date). Additionally, each chapter lists the publications that the chapter is based on.

Gómez-Maureira, Marcello A., Max van Duijn, Carolien Rieffe, and Aske Plaat. 2022. "Academic Games - Mapping the Use of Video Games in Academic Contexts." In *International Conference on the Foundations of Digital Games*. FDG '22. ACM.

Gómez-Maureira, Marcello A., Isabelle Kniestedt, Giulio Barbero, Hainan Yu, and Mike Preuss. 2022. "An Explorer's Journal for Machines: Exploring the Case of Cyberpunk 2077." *Journal of Gaming & Virtual Worlds* 14 (1): 111–35.

Gómez-Maureira, Marcello A., Isabelle Kniestedt, Max van Duijn, Carolien Rieffe, and Aske Plaat. 2021. "Level Design Patterns That Invoke Curiosity-Driven Exploration: An Empirical Study Across Multiple Conditions." *Proceedings of the ACM on Human-Computer Interaction* 5 (CHI PLAY): 271:1–32.

Gómez-Maureira, Marcello A., Isabelle Kniestedt, Sandra Dingli, Danielle M. Farrugia, and Björn B. Marklund. 2020. “CURIO 2.0: A Local Network Multiplayer Game Kit to Encourage Inquisitive Mindsets.” In *International Conference on the Foundations of Digital Games*, 1–10. FDG ’20. New York, NY, USA: ACM.

Gómez-Maureira, Marcello A., Isabelle Kniestedt, Max J. van Duijn, Carolien Rieffe, and Aske Plaat. 2019. “Shinobi Valley: Studying Curiosity For Virtual Spatial Exploration Through A Video Game.” In *Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, 421–28. Barcelona Spain: ACM.

Gómez-Maureira, Marcello A., and Isabelle Kniestedt. 2019. “Exploring Video Games That Invoke Curiosity.” *Entertainment Computing* 32 (December): 100320.

Gómez-Maureira, Marcello A. 2018. “CURIO: A Game-Based Learning Toolkit for Fostering Curiosity.” In *Proceedings of the 13th International Conference on the Foundations of Digital Games*, 1–6. Malmö Sweden: ACM.

Gómez-Maureira, Marcello A., and Isabelle Kniestedt. 2018. “Games That Make Curious: An Exploratory Survey into Digital Games That Invoke Curiosity.” In *Entertainment Computing – ICEC 2018*, edited by Esteban Clua, Licinio Roque, Artur Lugmayr, and Pauliina Tuomi, 76–89. Lecture Notes in Computer Science. Cham: Springer International Publishing.

2 Perspectives on Games, Curiosity, and Exploration

This chapter introduces literature from game research, game studies, and behavioral psychology in the context of curiosity. These areas form the theoretical foundation of the larger investigation into games that elicit curiosity for exploration and the strategies that are employed in doing so.

The chapter defines “games” as a medium. It discusses using games for purposes beyond entertainment (i.e., applied games), such as motivating curiosity for a topic through games, teaching with games, or using games as research artifacts.

Subsequently, terminology and definitions surrounding the concept of curiosity and how scholars have operationalized it in prior studies are discussed. The chapter concludes with the author’s work on the intersection of these topics.

2.1 Defining Games

Games are commonly considered “fun” activities, providing entertainment through the engagement of involved participants: the players. As a medium, games may provide that entertainment through different means, such as providing pleasure through appealing aesthetics, surmountable challenges, or agency in how narrative events unfold, to name a few. Formal definitions of games focus on describing the conceptual artifact in its physical or virtual manifestation rather than the emotional impact it creates in a player. Avedon and Sutton-Smith’s book *The Study of Games* (2015) defines games as:

> "... an exercise of voluntary control systems, in which there is a contest between powers, confined by rules in order to produce a disequilibrial outcome."

In Jesse Schell's book for aspiring game designers *The Art of Game Design* (2008), this definition is unpacked and compared to definitions from other scholars, ending with a simplified definition by Schell that introduces the emotional aspect (i.e., playfulness) that is often associated with games:

> "A game is a problem-solving activity, approached with a playful attitude."

Schell's definition of games foregoes specifying the systems and circumstances outlined by Avedon and Sutton-Smith, focusing instead on the affective state of players. Rather than understanding these definitions as competing assessments on the nature of games, they reflect different focus points and are meant to illustrate that the formal definition of games remains in active discussion. However, both definitions describe games as ontological entities, as conceptual systems that are framed as constituting a game in the mind of potential participants.

What is less explicitly mentioned but implicit in the notion of rules and activities is the involvement of one or more game designers. As a profession, game designers define the actions that players can take, the actions that are carried out by elements in the game, and the aesthetic through which these actions are communicated to players. Designers may further frame these actions through narrative structures to contextualize the game's actions and emotionally engage the player.

Although playful activities can and do emerge without intentional design (Salen and Zimmerman 2005), games are authored with a purpose and involve strategies that support the realization of that purpose. For many games, that purpose is to entertain players for the duration of their involvement with the game. The entertainment value drives the perception of games being "fun" despite involving a wide range of affective states that can, at least in the moment, be considered negative (Lazzaro 2009; Bopp, Mekler, and Opwis 2016). Games frequently present players with challenging tasks requiring physical dexterity or involve narrative elements that convey sadness or fear. Providing entertainment in this context is thus not necessarily a moment-to-moment goal but rather the subsequent appraisal of a player's time with a game.

In this work, games are defined as *intentionally bounded systems, designed to facilitate cognitively or affectively engaging scenarios through interaction.* This understanding builds on the earlier definitions, with a more explicit focus on authorial intent.

Inherent in this way of understanding games is *the existence of purposeful authorship during the creation of scenarios and the realization of purpose through interaction in a manner that invokes the attention of players.*

The definition of video games is necessarily based on the definition of games while further specifying how a game is played and presented. Tavinor (2008) argues that:

> "X is a videogame if it is an artefact in a digital visual medium, is intended primarily as an object of entertainment, and is intended to provide such entertainment through the employment of one or both of the following modes of engagement: rule-bound gameplay or interactive fiction."

While Tavinor's definition of games as involving rule-bound gameplay or interactive fiction is another perspective that partially overlaps with what has been discussed previously, it emphasizes the use of a digital display as a significant part of video games. Video games, in turn, can be considered a subgroup of "digital games", which also covers games that do not output to a video display. Examples include physical chess boards with digital components (Square Off, Inc 2022), hybrid board games (Rogerson, Sparrow, and Gibbs 2021) or audio-based exercise games such as *Zombies, Run!* (Six to Start 2012). However, the work presented in this thesis is focused on video games as they all involve the presentation through a digital visual medium.

The development of video games started as single-person projects and creations of a small group of authors exploring the capabilities of nascent personal computers (Williams 2017; Wolf 2008). As video games became commercial products, companies started to emerge and professionalize the development of video games (Wolf 2012). Especially the creation of video games for home consoles (specialized personal computers meant to run video games) required access to specialized development equipment unavailable to the general public.

Video game development has been influenced by both software development and creative industries such as movie production (Engström et al. 2018). However, the combination of tasks involved in game development, including coding, storyboarding, world-building, and user-testing among other tasks, presents unique challenges that require specialized expertise. Unlike movie productions, games pose “second-order design problems” (Salen Tekinbaş and Zimmerman 2003), which arise from the interaction between players and the designed game system. Unlike software development, this interaction is not purely utilitarian, but is also expected to be emotionally engaging and entertaining.

Over time, the tools to make video games have become more accessible regarding the necessary equipment and required programming knowledge (Nicoll and Keogh 2019; Nicoll 2019). This has, once again, made commercial game development viable for small teams and individuals (Iuppa and Borst 2012). Similarly, it has enabled the creation of games as tools for purposes other than entertainment (Wilkinson 2016).

2.2 Applied Games, Serious Games, and Gamification

Outside the entertainment industry, “serious” games are frequently created with a non-entertainment purpose, e.g., to impart information or collect data through game elements. Such games may still be experienced as entertaining; in fact, the potential entertainment value remains an essential quality for the efficacy of serious games (e.g., Ritterfeld, Cody, and Vorderer 2009; Klopfer, Osterweil, and Salen 2009) as it directly relates to how motivating or engaging the game is expected to be. However, entertainment plays a supporting role for the primary purpose, often in the form of providing training or experiential simulations of hypothetical scenarios (Bogost 2007). With the notion of “seriousness” not necessarily matching the aesthetics or apparent design of a game that has been created for non-entertainment purposes, other labels such as “applied games” or “gameful design” have been proposed and are frequently used in the related literature (Deterding et al. 2011).

In this work, the term serious games should be understood as synonymous with “applied games”; a term that is more apt in describing how games are employed. “Serious” refers here to *applying games in settings that are otherwise not considered to involve games.*

Applied games can be considered an umbrella term for several subfields that involve the use of games. Game-Based Learning (GBL) and educational games in general (Tobias, Fletcher, and Wind 2014) deal with the use of games to support formal education and lifelong learning efforts (Berg Marklund 2015). "Games for Health" (Wattanasoontorn et al. 2013) are intended to promote activities and provide information to influence health care positively. "Exergames" (Sinclair, Hingston, and Masek 2007) are created to improve players' physical performance and related lifestyle behaviors. "Advergames" (Terlutter and Capella 2013) are created to promote awareness or evaluate products and companies.

Explicitly excluded under this umbrella is the area of "gamification", following Deterding et al.'s (2011) definition of gamification as …

> "… the use of game design **elements** in **non-game contexts**" (emphasis added)

Applied games are defined by their purpose while maintaining a game-like context. By this definition, a context can involve gamification or be an applied game, but not both simultaneously. A gamified banking application, for example, may employ terminology associated with games (e.g., achievements, levels, and points), but it does not present itself as a game; the applied context is dominant over the game elements that are employed within it. On a practical level, what separates gamification from applied gaming is the amount and necessity of game design elements and the framing of these elements in the context in which they are used.

2.2.1 Game-Based Learning (GBL)

GBL, one of the subfields mentioned earlier, deserves further elaboration as it is the context of a case study presented in Chapter 3. GBL promises to motivate players through commonly used game elements, such as involving a clearly defined goal, providing rewards, and delivering frequent feedback (Kickmeier-Rust et al. 2011). The interactivity offered in GBL is intended to support the understanding of subject matter, ideally through active experimentation instead of relying on passive absorption of knowledge (Ko 2002).

From the perspective of many proponents of game-based learning, games are viewed as a medium in which the current generation of students, who grew up with games and technology as easily accessible consumer products, excels (Bellotti et al. 2009; McClarty et al. 2012). Children are said to easily navigate game environments, regularly employ problem-solving methods, engage in advanced collaborative efforts, and communicate complex concepts to one another during their private gaming sessions at home (Bogost 2007; Egenfeldt-Nielsen 2006; Gee 2003). Seeing young students relish in activities that are seen as fundamentally analogous to what teachers work hard to interest them in is a catalyst for wanting to harness "the power of games" for educational purposes (Kickmeier-Rust et al. 2011; McClarty et al. 2012; Shapley et al. 2011).

However, even though the discourse and interest surrounding GBL is continuously growing, the type of widespread implementation that has long been predicted and anticipated is yet to happen (Egenfeldt-Nielsen 2010). One reason might be that games, on their own, do not facilitate learning as effectively or automatically as one might hope. For example, game designer Raph Koster (2014) has defined games as systems that teach but adds that they ultimately only teach the player to identify game patterns and to hone the skills necessary to perform well in the confines of those patterns. This, in essence, is the focal point for the continuously ongoing debate regarding the transfer of acquired knowledge in serious games and game-based learning (e.g., Tobias et al. 2011).

While games can encourage students to become intrinsically motivated learners beyond only imparting and testing knowledge or training skills (Mozelius 2014; Bullard 2016), this approach is currently not the most common for games used in classrooms. A survey of 700 US teachers showed that the primary reasons for using (digital) games in classrooms are to teach new material, to practice already learned material, and to reward or give a break to students (Takeuchi and Vaala 2014). The survey also shows that games used in classrooms tend to focus on a specific subject (e.g., literacy or math). This is understandable, as educational content is time consuming and expensive to make, but it also limits the use of a single game. The resulting games can be predictable and lack variation (Lopes 2010). While more intricate, commercial games, such as *Roller Coaster Tycoon* (Sawyer 1999; Kirriemuir and McFarlane 2003) can provide educational experiences on a range of topics (e.g., economics and physics), they pose other challenges in incorporating them into the curriculum (Kirriemuir and McFarlane 2003; Wagner and Wernbacher 2013).

In addition to integrating fixed, educational content (W. Ryan and Charsky 2013), the emphasis is also often placed on the game and the student. While teachers may use gameplay as a starting point for discussion, devise quizzes around a game, or gather data from built-in assessment tools (Takeuchi and Vaala 2014), the teacher is rarely involved in the play experience. Changing this may, in part, help to increase the perceived usefulness of games as classroom tools, a lack of which forms a barrier to teachers adopting games in their practice (Proctor and Marks 2013).

Figure 2.1: Screenshots of games used in GBL contexts. Left: *Roller Coaster Tycoon*, right: *Ludwig*.

While GBL has potential, the development of educational games remains a challenge. Aside from ensuring technical functionality and meeting the expected level of audio-visual fidelity, they are expected to have a demonstrable impact on a player's educational progress. The example of *Ludwig* (see figure 2.1), an educational game created to teach students about renewable energy production in the classroom, serves as a case study that successfully afforded the transfer of knowledge (Wagner and Wernbacher 2013). At the same time, the authors note that the learning progress requires the active involvement of teachers: "Classroom learning, in particular at the elementary and middle school levels, is driven by the interaction between the teacher and the students" (Wagner and Wernbacher 2013). This is noteworthy because the design of *Ludwig* does not address the involvement of a teacher or the use within the classroom. Despite this, the authors note that it succeeded in making students curious and motivated them to learn.

Despite the challenges, previous work has often found a balance between featuring educational and engaging content (Egenfeldt-Nielsen 2011; McClarty et al. 2012; Young et al. 2012).

2.3 Curiosity and Exploratory Behavior

Prior research efforts into curiosity have taken place predominantly in the fields of philosophy (Inan 2013; Schmitt and Lahroodi 2008) and psychology (Dewey 1910; Berlyne 1954). Inherent in this past is that definitions of curiosity vary, ranging from accounts of human aspirations to describing it as a stimulant for interaction with the environment.

Curiosity can be understood as an intrinsic motivation for pursuing new knowledge and experiences that are accompanied by pleasure and excitement. This understanding of curiosity is based on a meta-review of academic articles which aimed to find commonalities in prior research (Grossnickle 2016). In the review, the author discusses different research lenses through which curiosity has been studied. These lenses do not necessarily contradict each other but focus on different aspects of curiosity. One view of curiosity, for example, is to consider it a primal drive that requires satisfaction (Berlyne 1954, 1960), not unlike satisfying hunger (Schmitt and Lahroodi 2008).

Another view is to see curiosity as a need to fill gaps in knowledge (Loewenstein 1994), requiring both existing knowledge to be aware of such a gap, as well as the evaluation that the gap is neither too wide nor too insignificant to be filled (Spielberger and Starr 1994). The "information gap theory" focuses on the cognitive circumstances that elicit curiosity in broad terms. Loewenstein (1994) writes that …

> "[…] the information-gap theory views curiosity as arising when attention becomes focused on a gap in one's knowledge. Such information gaps produce the feeling of deprivation labeled curiosity. The curious individual is motivated to obtain the missing information to reduce or eliminate the feeling of deprivation."

For curiosity to arise under the information gap theory, an individual must perceive that an information gap exists. It further notes that the motivation to obtain missing information is greater if the gap is experienced as potentially surmountable. In other words, curiosity arises when someone is aware that there is something to understand, and there appears to be a possibility for understanding it, given actions that could be taken.

While the information gap theory looks at the *state of curiosity* as an "in-the-moment" drive for exploratory behavior (Loewenstein 1994), the focus can also be on a person's likelihood of becoming curious, i.e., *understanding curiosity as a personality trait*. Trait curiosity is an individual's tendency or disposition to become curious and is considered a relatively stable personality trait (Litman and Silvia 2006). It should be noted that studies have shown a correlating relationship between trait and state curiosity (Litman, Collins, and Spielberger 2005; Kashdan and Roberts 2004; Reio and Callahan 2004). The "I/D" model of curiosity (Litman and Jimerson 2004) describes curiosity as a trait that consists of two motivational parts for acquiring information. Closing an information gap to reduce the feeling of deprivation is the "D" part of the I/D model. It is in contrast to the "I" part, which describes being motivated by an interest in acquiring information. The two types are described as a continuum between "Needing to know" and "Wondering about".

Another lens through which curiosity can be conceptualized is by the modes of exploration that are perceived as likely to satisfy it, as described by child psychologists Kreitler et al. (1975a), who posit five factors of understanding through curiosity:

1. Manipulatory curiosity – through physical interaction
2. Perceptual curiosity – through perceptual stimuli (e.g., touch, sight, or sound)
3. Conceptual curiosity – through the epistemic nature of stimuli
4. Curiosity about the complex – through contradictory or multidimensional stimuli
5. Adjustive-reactive curiosity – through the verification of expectations

While curiosity can be felt without leading to exploration, it is externalized through exploratory actions. Thus, exploration can be understood as the behavioral expression of the emotional sensation of feeling a desire for novel information or feeling a strong lack of specific information. This makes exploration a distinct phenomenon that is nevertheless closely intertwined with the experience of curiosity. As such, it is also frequently what is being measured in efforts of quantifying curiosity as a state (e.g., Jirout and Klahr 2012).

The term "exploration" can refer to the actual traversal of physical space to gain information (and thus to satisfy curiosity), but it can also refer to covering a conceptual space of possible actions or cognitive interpretations of information. It can also be part of a dynamic that is directed towards the curiosity and exploratory behavior of others, thus exploring a social space.

These three domains of exploration — spatial, conceptual, and social — can involve different modes of exploration and are further impacted by someone's overall disposition of becoming curious, i.e., their trait curiosity.

Much of the current work in quantifying curiosity is concerned with measuring trait curiosity (Litman and Jimerson 2004; Litman 2008) or related personality traits, such as intrinsic motivation (Day 1971; McAuley, Duncan, and Tammen 1989) or sensation seeking (Zuckerman 2007). One of the more recent efforts is the curiosity model proposed by Kashdan et al., which suggests the involvement of five dimensions to describe an individual's disposition to become curious (Kashdan et al. 2018). The dimensions are:

1. Joyous exploration – being motivated by novelty
2. Deprivation sensitivity – having a need for resolution
3. Stress tolerance – the ability to cope with uncertainty
4. Social curiosity – wanting to know about others
5. Thrill seeking – taking pleasure in managed anxiety

The individual dimensions were selected based on preceding work and validated through three surveys. The result of their study is the Five-Dimensional Curiosity Scale (5DC), which quantifies trait curiosity through a validated questionnaire. This thesis further builds upon this work in Chapter 4 by using the 5DC to examine what types of games are best at eliciting various types of exploration.

2.3.1 Curiosity and Exploration in Games

While many things can elicit curiosity, games present one of the more focused efforts in making people feel curious and act on their curiosities. Costikyan's work regarding the role of uncertainty in games, for example, involves curiosity and describes it as an essential motivator to engage in gameplay (Costikyan 2013). For Klimmt (2003), curiosity is part of a conceptual model for player engagement, i.e., why people choose to play games.

Studies into player profiling seek to establish player archetypes that involve personality traits and motivations, including curiosity (Schaekermann et al. 2017). Interestingly, such player archetypes can directly mirror aspects of Kashdan et al.'s aforementioned curiosity model. The *BrainHex* model (Nacke, Bateman, and Mandryk 2011) features seven archetypes that match the characteristics of different dimensions of curiosity. For example, the "daredevil" archetype is defined as taking pleasure in taking and overcoming risks, matching the "Thrill Seeking" dimension in the 5DC. In these cases, however, curiosity is not studied on its own but is mentioned as a contributing factor.

Games have been proposed as instruments for measuring curiosity, as was done in a study from 2012 to measure scientific curiosity in children (Jirout and Klahr 2012). In that experiment, players' performance within an exploration game served as a behavioral measure instead of relying on self-report through a questionnaire.

An improved understanding of curiosity also benefits efforts in understanding player experience and can inform game development. To et al. (2016) investigated how video game designers elicit players' curiosity. In their study, they provide examples from commercial games that are designed to trigger and satisfy different modes of curiosity based on Kreitler et al., as described before.

These works show that games, whether in physical form or as video games, can elicit curiosity as an intentional part of their design. However, prior work has not investigated the development and design processes that promote player exploration. This makes it difficult to know how the promise of eliciting curiosity through games can be realized in practice.

2.4 Conclusion

The work presented in this thesis seeks to expand on the present literature through the practice of designing for curiosity and exploration. This chapter introduced the necessary fundamental concepts and relevant perspectives that the practical work in the following chapters is based on.

The chapter described the medium of study in this thesis: video games. It further specified the notion of applied games (i.e., games with purposes other than pure entertainment) and, more specifically, game-based learning. It then presented notable literature on curiosity, its various forms, and the exploratory behavior it motivates. Finally, it provided an overview of literature where the study of video games and curiosity overlap and showed how much is still unknown about how curiosity is elicited in games.

This thesis further builds upon the knowledge presented in this chapter. This work investigates games as a medium through which curiosity and the resulting exploration behavior are elicited. Chapter 3 presents the first practical case study, *CURIO*, an example of an applied game designed to elicit curiosity for new topics in school children that builds upon previous literature on game-based learning.

Next, Chapter 4 builds upon the 5DC questionnaire (Kashdan et al. 2018), examining connections between different types of games and forms of curiosity. Chapter 5 then discusses the formulation of "design patterns" (further explained in that chapter) based on these different types of games and the curiosity they elicit.

The second game developed within the context of this work, *Shinobi Valley*, presented in Chapters 6 and 7), is an example of an applied game created for research purposes. It aims to elicit exploratory behavior that may be measured and studied, further building upon the existing literature on curiosity within games.

Finally, informed by the work that came before it, Chapter 8 continues to build upon the applied game literature by defining a new sub-type of applied game: academic games, i.e., games employed as tools for satisfying academic curiosity.

3 Creating a Game-Based Learning Toolkit for Fostering Curiosity

Chapter 2 outlined previous research on curiosity in and through games and the concept of game-based learning. The literature review showed how game-based learning efforts often focus on practicing learned material rather than stimulating curiosity. Additionally, literature looking specifically into how games elicit curiosity is limited. Thus, while games may seem like potential vehicles to elicit curiosity and exploration, e.g., in service of learning practices, it is not clear how that should be designed for and achieved.

The chapter examines how a game can be designed to elicit curiosity. It focuses on conceptual curiosity (Kreitler, Zigler, and Kreitler 1975a) when children are introduced to a new topic of study in school, with the externalization of that curiosity (i.e., exploration) being the formulation and discussion of questions.

> The research question that guides the work in this chapter is:
> **How can a game facilitate conceptual exploration?**

The study in this chapter describes the iterative development of *CURIO*, a game-based learning toolkit (also referred to as "gamekit" from here on) designed to support teachers in fostering conceptual curiosity in students. The project is funded by the *Erasmus+ Cooperation for Innovation and the Exchange of Good Practices* scheme with the goal of promoting interest in Science, Technology, Engineering, and Mathematics (STEM) subjects for children in primary education. As the project aims to stimulate interest in STEM (science, technology, engineering, and mathematics) topics in Malta, the game has to meet the needs of teachers and students in Maltese schools.

The study addresses the following research questions through a game artifact:

1. Can a classroom game around asking questions support teaching?
2. Does such a game elicit curiosity for topics presented as part of it?

The study's outcome is the development of the *CURIO* gamekit, informed by a user-needs analysis, an initial prototype development, and a re-designed game that is tested in a Dutch classroom. The game was developed by a core team consisting of a designer & programmer (the author of this thesis) and a designer & artist, with additional work outsourced to one freelance developer and one artist.

The chapter first describes the preliminary work in performing a user-needs analysis of the involved stakeholders through a series of focus groups (section 3.1). Based on the requirements resulting from this analysis, and additional requirements set out by the project design, a prototype (section 3.2) is designed that offers distinct gameplay to both students and teachers. The prototype is subsequently iterated to fit changing circumstances and needs of the stakeholders. This process results in the final version of the game, the *CURIO* gamekit (section 3.3). Before concluding the project development, the gamekit is evaluated with 25 Dutch elementary school students (section 3.4). Results of the evaluation study suggest that teachers and students see value in a classroom game emphasizing inquisitiveness as part of its gameplay. Students also appeared to show increased awareness of and interest in topics featured in the evaluation study, indicating that the game successfully elicited curiosity. The chapter concludes with a reflection on the gamekit, its potential use in classrooms, and its ability to elicit conceptual curiosity in children for a new topic of study (section 3.4.3).

Chapter Publications

Work presented in this chapter has been published in these peer-reviewed venues:

- **International Conference on the Foundations of Digital Games (FDG) – 2020**
  "CURIO 2.0: A Local Network Multiplayer Game Kit to Encourage Inquisitive Mindsets" (M. A. Gómez-Maureira et al. 2020)
- **International Conference on the Foundations of Digital Games (FDG) – 2018**
  "CURIO: A Game-Based Learning Toolkit for Fostering Curiosity" (M. Gómez-Maureira 2018)

3.1 User-Needs Analysis

The development of educational games often focuses on benefitting students. However, prior Game-Based Learning (GBL) work has shown the need to consider other stakeholders. In addition to students, teachers, parents, and developers are all part of developing a successful outcome (Berg Marklund 2015; Marklund, Backlund, and Engstrom 2014).

In the development of *CURIO*, the needs of teachers are prioritized above those of other stakeholders. This is because it is ultimately the role of teachers to evaluate what supporting tools are viable in the classroom. While there are several factors that teachers cannot influence, at least within a typical Maltese classroom, teachers will not use teaching instruments that do not support their teaching style. As the development progresses, students and parents are asked to provide feedback. Their perspective also shapes the game, although to a lesser extent than that of teachers.

In order to get a better idea of what teachers expect from an educational game played within the classroom, three focus group sessions were conducted with 15 teachers in total.

3.1.1 Focus Group Sessions

The three focus groups conducted before the development of *CURIO* followed the procedure outlined in this section. Each group consisted of 5 teachers from STEM fields with ages ranging from 20 to 60. Five topics were used to guide the discussion over 1.5 hours:

1. Teachers were asked to reflect on what they considered to be the meaning of scientific curiosity. Their reflection included the definition of curiosity and its purpose within education.
2. The groups discussed which subject matter readily elicits curiosity in their students. Teachers were asked to contrast this with topics less likely to make students curious.
3. Teachers discussed using digital tools in the classroom and as part of formal education in general.

4. Teachers were asked to discuss what aspects of a classroom game support their teaching efforts and how to prevent such a game from impacting a teaching session negatively.
5. Teachers were asked to discuss noteworthy examples of digital tools that support teaching efforts and make students curious to learn more.

The outcome of the focus groups was that ease should be the most crucial aspect of GBL efforts. Teachers emphasized that educational games for the classroom need to be mindful of the time and resources they can provide. This notion was most apparent when teachers discussed the essential focus of *CURIO*. Besides ease of use, teachers mentioned that students are often not the "digital natives" they are assumed to be. Teachers further highlighted the need for flexibility when teaching and the need to stay in control of the classroom at all times, a challenge, especially when involving technology in the classroom.

Another important aspect is a close relation to the teaching syllabus. Focus group participants noted that students would be happy to play games throughout the lesson but, on the other hand, must pass formal exams at some point. Other aspects that focus group participants mentioned include the need for an appealing visual design, support for group work, functional independence from the Internet, the ability to facilitate different interests, and an overview of past activities for review purposes. It should be noted that the teachers occasionally offered specific design ideas that were not further assessed in detail. Examples include suggestions to involve as many activities as possible, the addition of comics, or the use of "bubbles with interesting facts." Instead of understanding these suggestions as crucial features, they are considered elements that teachers believe students would like to engage with.

When teachers were asked for noteworthy examples, they mentioned *Kahoot!* (Dellos 2015) as a game that stands out in usability and in its ability to encourage participation. Generally, games that were mentioned were explicitly created for educational purposes instead of entertainment games repurposed for learning purposes. The modification of existing games, such as *Minecraft* (Nebel, Schneider, and Rey 2016), was not brought up.

In the context of curiosity, interviewees agreed on its importance for facilitating learning but had difficulties describing what it entails. Curiosity was defined with related attributes, and participants could not agree on whether it requires some existing knowledge or whether it can be elicited without any prior interest or knowledge. For educational purposes, curiosity was described as “wanting to know”, asking many questions, exploring, and experimenting. Teachers noted the importance of letting students come up with their answers and cautioned that formal education could “kill curiosity with facts”. When asked to discuss suitable topics to elicit curiosity in STEM, the interviewees noted that the presentation had a more significant impact than the topic itself. They highlighted that students require relatable real-life examples but also the use of topics that are neither too difficult nor too easy.

3.1.2 Additional Requirements

In addition to eliciting curiosity in students, *CURIO* has to support teachers specifically in areas of STEM. *CURIO* is developed for use in Maltese schools, which have identified a need to promote STEM areas. While Malta has taken action to improve student performance, the *Program for International Student Assessment* has ranked Malta as one of the lowest-scoring countries in the European Union (OECD 2016). As a result, the design of *CURIO* needs to support education efforts in one specific subject and across different STEM fields.

The technological limitations within the classroom set out further requirements. The *CURIO* project is based on the *One Tablet Per Child* initiative to provide every child in Maltese primary schools with a tablet device for learning purposes. Thus, the game should ideally be developed to run on these tablets and within the school infrastructure. Usability for teachers and students using this technology is essential.

Finally, developers need to balance the needs of users with what can be created by the available development staff. The *CURIO* development team is small (i.e., two developers), thus restricting the technical and aesthetic complexity compared to high-budget games. Ideally, all stakeholders are considered and can influence the development process. However, prioritization is necessary when resources are limited.

3.2 Initial Prototype

This section describes the initial prototype design of *CURIO* and how insights from related work and focus groups helped to shape it. It should be noted that, as is often the case in the iterative development of projects, the design of the game changed over time. In the case of *CURIO*, the game underwent a significant change after initial development conclusions, as the initial plan was deemed too ambitious to be fully realized (see section 3.2.5). This assessment led to the development of a new design described later in section 3.3.

3.2.1 Prototype Design

For the prototype, *CURIO* is designed as a real-time, multi-user classroom game in which students are tasked with answering exam questions through text input or by providing images. If a question asks to name animals with more than four legs, the text input “spider” would be just as valid as an image showing a spider.

The game’s goal is to decorate a virtual game environment set upon the backdrop of an exam paper (seen in figure 3.1), which is done by posing new questions about the answers that other players have already provided. Decorations are thus created not by answering the exam question directly but instead by posing new questions about the answers that have been given. As such, the game’s focus is on developing new questions. At the same time, these questions can only be asked if answers have been proposed, thus requiring both the formulation of questions and answers to make progress in decorating the environment.

Players in the game are guided and supervised by a unique player character that is reserved for the teacher. Teachers supervise game sessions through a game terminal that also serves as a shared overview for students in the classroom, e.g., through a video projector. Outside classroom sessions, students can customize their player avatars, while teachers can add or modify exam questions and additional content to support students.

The game aims to support teachers by providing a group environment that encourages students to conceptually explore a question beyond the direct answers that can be given. *CURIO* aims to present itself as an educational instrument from the start rather than over-emphasize its game elements. The rationale is that certain formal education elements, such as exam papers and workbooks, are a reality for students in Malta. The involvement of game-based learning tools is not likely to change the format of an entire education system, at least not overnight. Positioning *CURIO* as an interactive preparation for an exam means that game elements can surprise players. While this shift in the presentation may be subtle, it is preferable over players expecting a game for entertainment purposes that then reveals itself as a tool for learning; something that has been aptly referred to as "chocolate-covered broccoli" (Granic, Lobel, and Engels 2014).

This does not mean that entertainment is not a factor in *CURIO*. However, it is not the first priority, as is arguably the case for GBL applications in general. Besides its role to support students, *CURIO* provides teachers with a tool to manage group activities by giving them control over digital devices used in the classroom and providing data that can inform their formal teaching efforts.

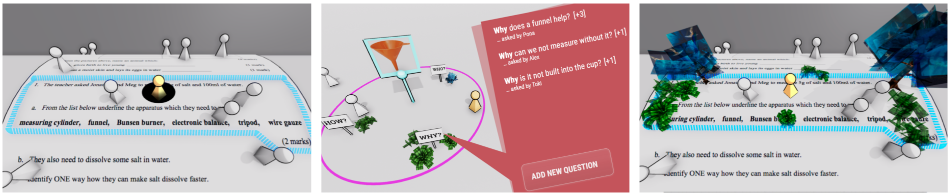


Figure 3.1: Three screenshots of the initial prototype. The first shows the exam hub and a player entering a question. The second shows the player in an entered question level next to a "planted" answer. The interface shows which follow-up questions have been added by other players. The last image shows the exam hub again, and the decorations that are created as part of adding follow-up questions.

3.2.2 Design Considerations

The insights gathered in preparation for the *CURIO* project have led to three considerations that guided the game's design.

GBL in the Classroom: Both prior work and the focus groups show that games in the classroom need to be designed for the role of teachers. In *CURIO*, this should be done in two ways. First, teachers are players, put in charge of facilitating gameplay for students and acting as participants themselves. Second, teachers control the access to the game for all players and can use that control to create moments for discussion at any time. For this reason, the initial prototype of *CURIO* does not feature a dedicated end state and is, instead, a playful activity that can be suspended at any moment. The game can be considered simple in terms of its interactive features, as players have only a few options for interaction. This simplicity is by design and should allow a better focus on formulating answers and follow-up questions within the game. It further means that players do not need to learn complex control schemes, which should ease concerns about difficulties with operating the game. In terms of content, *CURIO* starts with a formal educational element that is the cause of much anxiety in students: an exam paper. In decorating an exam paper through conceptual exploration, the game may alleviate some of the anxiety and signal to teachers that using *CURIO* can be part of preparatory lectures.

Eliciting Curiosity: While curiosity can be satisfied, it is often part of eliciting further curiosity about what has been learned (Schmitt and Lahroodi 2008). In *CURIO*, this process is at the heart of its gameplay, as progress is achieved by coming up with follow-up questions to answers given. This also follows from focus groups where teachers highlighted the importance of formulating new questions. Another aspect that was mentioned is experimentation and exploration. Both aspects are present in CURIO, although from a largely conceptual perspective, such as considering what follow-up questions can relate to a given answer. Following To et al.'s suggestions regarding designing for curiosity (To et al. 2016), different methods of eliciting curiosity are considered. “Perceptual curiosity” is invoked by seeing other players' activity through the size of planted answers (and thus a wealth of connected follow-up questions) and having to interact with them to find out more.

Another example is the search for hidden objects and the chance that a hidden object turns into an interactive machination. “Manipulative” and “Adjustive-Reactive Curiosity” are meant to be elicited by the involvement of such machinations, as players can experiment with simulated physical processes. “Curiosity about the Complex and Ambiguous” is meant to be elicited by seeing other players' answers and follow-up questions. These might not always be clear and require further clarification, either by a direct conversation in the classroom, or by posing follow-up questions within the virtual environment. “Conceptual Curiosity” is the most prominent method of eliciting curiosity in *CURIO* through having players formulate follow-up questions. The depth of such exploration then depends on whether teachers involve additional material, such as existing textbooks, to formulate answers.

STEM and Player Enjoyment: As previously mentioned, *CURIO* seeks to benefit efforts to improve student performance in STEM fields. Besides this, player enjoyment is another essential factor in ensuring prolonged use. As STEM already consists of a range of fields, it is primarily the methodology that provides a common ground that is promoted in *CURIO*. At its core, all STEM fields require formulating questions that can be the basis for experimentation and further analysis. Formal education often teaches knowledge that has been acquired without emphasizing the transient nature of such answers. In focusing on the importance of follow-up questions, *CURIO* aims to increase students' performance in STEM fields not by teaching the underlying content but by presenting an approach to gaining knowledge. At the same time, by using content from STEM fields and implementing interactive objects for experimentation, *CURIO* also aims to offer more traditional ways to engage students with content from STEM. It is important to note that player enjoyment in the game is not meant to rival games that are developed for the sole purpose of providing entertainment. Instead, game elements such as player customization, a friendly visual aesthetic, and "juicy" feedback elements (Juul 2010) increase the enjoyment of activities that can be carried out in the game.

3.2.3 Gameplay for Students

In *CURIO*, both students and teachers are considered players. The game is intended for a single teacher and 10-30 students. Student players and a teacher take on different roles in the game, but both access the same game environment and can see and interact with each other within it. Players assume control over a customizable virtual avatar that navigates a 3-dimensional environment from a third person perspective. The game environment depicts an oversized exam paper, with players being able to walk on top of it (see the first image in figure 3.1). Players can access exam questions with their virtual avatars. This leads them into a separate 3D environment that represents the conceptual space of the question. In other words, each question can be considered a game level, while the exam paper acts as a hub environment that allows players to choose which level to access.

In the beginning, levels appear to be empty. Here, players can send out shockwaves to reveal hidden objects in the environment. These objects can be collected, which turns them into potential answers to the question that has led to the level. Every collected answer is added to a shared inventory that all players can access. Players can also add answers at any time, both as text or image (e.g., via a mobile device's camera). To provide an answer to a question, players access the inventory and select an answer they want to plant into the level. This creates a 3D object in the level that represents the given answer. Each planted answer in the level allows players to pose questions about that answer (see the second image in figure 3.1). Questions may ask for clarification but could also inquire about something that is only tangentially related to the original exam question. With each additional question, the planted answer grows in size within the level environment.

A small selection of hidden objects can also contain unique machinations that are placed within the level upon their discovery. Players can interact with them to visualize functionality, such as illustrating how the opening of a funnel affects water flow and pressure. Such objects are developed for specific topics and are available at the teacher's discretion.

When players return to the exam hub, they find that for each planted answer, a seedling has appeared on top of the exam question. These seedlings grow larger for each question players have posed about a planted answer (see the last image in figure 3.1). This means that most of the impact on the visual appearance of the exam hub comes from posing additional questions. While some exam questions might be simple enough to answer with a single answer, students are encouraged to come up with several answers that could contribute to the exam question and thus create more opportunities for asking new questions. The focus is, therefore, not on getting to a perfect answer but rather on encouraging students to think broadly about potentially relevant aspects. As such, teachers have to discuss with students why they think an answer contributes to an exam question and what follow-up questions are interesting to consider. In *CURIO*, this exchange is more important than whether the question is perfectly answered. At the same time, it also highlights that interactions in the game take place within both the virtual and the physical environment.

At the end of a game session, the exam paper hub should be overgrown with automatically generated vegetation and other visual elements. Since the extent of the coverage is directly connected to the number of questions that players posed, this visualizes how active players have been for each exam question. At the same time, this is the goal that players are asked to accomplish, although it functions closer to an open-ended high score than a binary winning condition. In summary, players in *CURIO* will go through the following sequence:

1. Choosing an exam question to work on and "enter"
2. Revealing hidden answer objects or creating new ones
3. Planting an answer, thus creating the possibility for asking follow-up questions
4. Adding new questions about planted answers
5. Repeating steps in a different exam question

Finally, the teacher ends every game session, which can be done at any time. Teachers are encouraged to discuss provided answers and follow-up questions that students have posed. This can also be done throughout a game session instead of just at the end.

3.2.4 Gameplay for Teachers

In *CURIO*, the teacher takes on the role of a facilitating player that, ideally, also finds enjoyment in that task. In pen-and-paper roleplaying games, so-called "game masters" guide the activities of participating players. Their role differs from that of other players, but they also engage in the game as players themselves. This is, essentially, the same role that a teacher should take in *CURIO*. Compared to student players, the teacher player has access to additional functionality and stands out by having a more prominent, faster-moving avatar in the game. Additional functionality includes teleporting between question levels, moderation of student players, and moderation of the game content. To moderate student players, the teacher can deactivate all student screens or disable player movement for moments of discussion. They can also teleport all or some players to their location within the game, which is useful when discussing specific answers or follow-up questions that have been added. Content moderation involves the ability to remove planted answers and follow-up questions by students in case they are deemed inappropriate.

Aside from the gameplay that takes place in the classroom, teachers are asked to prepare game sessions in advance. This means adding an exam paper into the game and highlighting areas that belong to an exam question for students to interact with them.

Teachers can then provide potential answers (which may or may not be correct) that will be distributed as hidden objects among the question levels.

3.2.5 Prototype Conclusions

The initial prototype of *CURIO* was designed to combine insights from prior work on curiosity-driven exploration, teachers' needs, and the development grant's requirements in a way that is both educational and entertaining for students. It sought to directly include existing teaching material in the form of exam papers and reframe the context away from assessment to perceiving a potential for conceptual exploration.

However, one type of stakeholder that was not taken sufficiently into consideration for the prototype was that of the (two-people) development team. Towards the end of the development of the initial prototype, it became clear that the amount of development work would not be sustainable to realize the proposed game design.

While development efforts typically undergo multiple iterative changes, these changes tend to become smaller in scope as the development progresses. This progression happens because substantive modifications at a later point become more costly in terms of development work. In the case of *CURIO*, the first quarter of the overall development time focused on creating a comprehensive game design based on what the development team believed could be achieved technologically and organizationally.

However, as time progressed, important development details kept changing. Eventually, *CURIO* is intended for use in Malta, where the public views game-based learning skeptically. For example, a suggestion received at the first public presentation of the project was to forego mention of the word "game". In Malta, games are closely related to gambling, based in part on the prolific local gambling economy. As such, educational and game design considerations also had to contend with political realities that made the development progress more challenging, requiring more time to organize playtesting and focus groups on the topic.

At the same time, technological infrastructure in the classroom turned out to be limited and varied between schools. In the end, this meant to develop *CURIO* in a manner that would allow for a broader range of target platforms and with ranging connectivity options while retaining the core of the game: to let students conceptually explore topics and do so in a shared virtual environment with their teacher. To retain the spirit of the game, the existing design and planned aesthetic had to change to complete development in the remaining time. Especially given that students and teachers need to feel confident in the consistent functionality of a game-based learning kit, the redesign removed some of the costlier design choices of the original game in order to provide that consistency.

Although a significant change in design is not necessarily standard in iterative development, it is also not unique to *CURIO* or game development in general. The funding realities of research projects can make it challenging to implement significant design changes, as a project is typically approved based on a proposed research design. However, in developing an applied game, work on the prototype can be instructive on whether a proposed design can be realized on the level of quality necessary to make it successful. In this case, it revealed that the initial design could not be realized without compromising on the implementation quality.

Public funding is typically granted based on a plan outlining how the partners will spend the received resources. Reworking a large part of a project can seem to run counter to this agreement. However, it can be argued that it is in the public interest to ensure that developers use funding in a manner consistent with the spirit in which it was granted. Doing so should be preferable over carrying out a plan regardless of what discoveries might occur during the project. In the case of game development (and possibly development efforts in general), making necessary changes might be prudent as long as it is possible to implement them with the remaining resources.

It is further essential to report such changes in academic literature. The development of serious games may otherwise appear to result from a series of iterative improvements in which no development work is ever lost. This is likely not the case, as the development of entertainment games frequently leads to work being discarded in light of new knowledge.

Even the redesign of *CURIO* presented in the subsequent sections is not guaranteed to succeed in providing teachers with a valuable teaching platform. Multiple evaluation studies, such as the one described in section 3.4, are required to assess whether *CURIO* can be considered a valuable tool for teachers. At the same time, maintaining the initial design would have required a different target environment or additional resources, neither of which would happen.

3.3 The *CURIO* Gamekit

This section describes the design of the *CURIO* "gamekit", a label chosen to indicate its use as a game-based teaching toolkit. The design is based on insights from the GBL field, designing for curiosity, results of focus groups with teachers, and development considerations of an initial prototype.

Figure 3.2: Screenshot of the *CURIO* gamekit website, showing one of the characters that players can encounter in the game.

In the *CURIO* gamekit, students work in groups to restore lost curiosity to a fictional galaxy besieged by the *Haze of Confusion*, the game's antagonist. The *Haze* sweeps across the galaxy, draining the planets' inhabitants of their enthusiasm for a particular topic. Students play individually but are sorted into three teams (blue, red, and yellow). By visiting the planets and asking the inhabitants questions, the students are tasked with helping them to regain interest in their topic. Eventually, students face the *Haze* and answer multiple-choice questions to defeat it. Once the students save the galaxy from the *Haze*, they can spend points earned during play to decorate their spaceship.

Game scenarios are prepared in advance by teachers for each game session. Scenarios determine the topics of the individual planets (conceptually functioning as subtopics grouped under a broader main topic) and the questions posed by the *Haze* in the final confrontation. For teachers, *CURIO* serves as a tool to engage students in a new topic, assess existing knowledge, and receive input for upcoming classes. While playing, the teacher acts as a game master who controls the game's flow.

3.3.1 Game Flow

Each game session consists of four parts: the beginning of the game, multiple game rounds, up to three endgame rounds, and a post-game sequence.

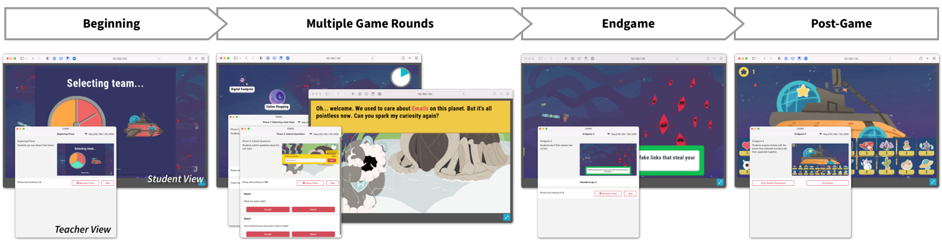


Figure 3.3: Diagram showing the four major parts of a game session. For each part, an example screenshot of the student and teacher view is shown.

The beginning of the game contains a short introduction that presents the topic of the game session and assigns players to one of three teams. The game session then goes through multiple game rounds in which players move from planet to planet to re-energize themselves by formulating questions about the topic. Game rounds consist of the following phases:

1. Setting a course by voting on which location to visit next
2. Landing on a planet based on the vote result
3. Generating curiosity energy by asking questions
4. Reviewing questions that were asked
5. Resolving the location visit

In the first phase, teams choose which planet to move to on a galaxy map of interconnected planets. In phase 2, teams land on a planet and are presented with a sub-topic. In phase 3, individual players formulate new questions about a sub-topic. In phase 4, teams see how many questions they created and which of those were considered noteworthy by the teacher. In phase 5, the performance of each team is evaluated, and questions are discussed in the classroom.

Each game round allows teams to move closer to an indicated target destination: the location of the *Haze of Confusion*. The duration of a game session depends on how long it takes the first team to reach the *Haze*, which then triggers the endgame for all teams regardless of their location on the map. Teachers can trigger this conclusion in the first phase of each game round to control the length of a game session.

The endgame is a confrontation between the *Haze* and the student teams at the end of a game session. At this point, players need to correctly answer questions about the session topic to combat the *Haze*. Each correctly answered question lets teams use their energy — acquired through creating questions throughout the game session — to disperse the *Haze*. The endgame itself consists of smaller endgame rounds in which the teams receive a question that needs to be answered, which is then resolved to show which teams answered correctly. By default, the endgame lasts for three rounds in which at least one team answers correctly. Teachers can change this setting both in the game setup and during the endgame.

All game rounds are synchronized among all players, meaning that individual players cannot proceed to the next round until all players are done. In practice, every game round takes place on a global timer or requires the teacher's confirmation. Timers can be modified by the teacher in the game setup and can be paused and resumed to facilitate discussion in the classroom at all times.

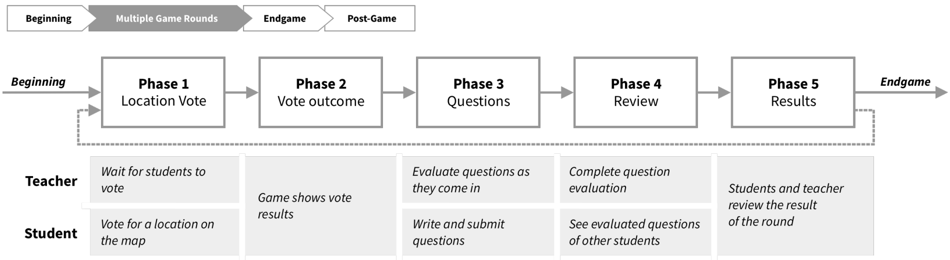


Figure 3.4: Flowchart of the five phases of a game round.

3.3.2 Student Side

This section describes students' actions in each of the four parts of a game session. The game starts with an animation that shows the *Haze of Confusion* spreading across a fictional galaxy. The sequence introduces students to the threat they need to defeat and then shows them which team they are part of. The introduction is followed by multiple game rounds, each broken down into individual phases.

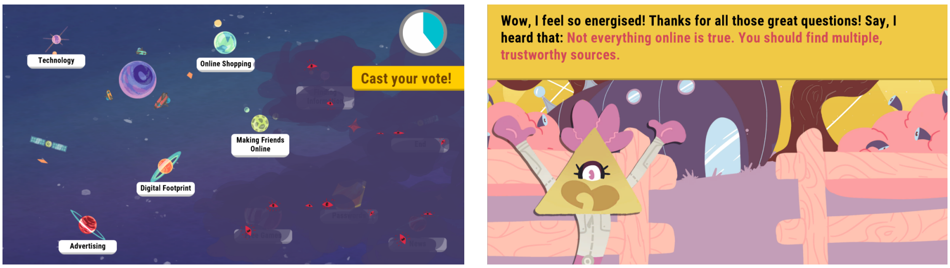


Figure 3.5: Screenshots of the student side of the game. Left: Main game screen, showing the map where students can vote for their next destination (i.e., sub-topic). Right: A planet's resident is shown to be re-energized by students' questions and shares some information about the current sub-topic.

Phase 1: Vote for target location

Students see the map of the galaxy, which shows the three player ships and several planets with sub-topics connected to them. The exact layout of the map is randomized upon starting the session. In this phase, students individually vote for which planet they want to visit. Most of the map will be covered by a "fog of war" at the start of the game, limiting the students' options. The neighboring planets will be unlocked as they visit planets and become available for selection. In the first round, player ships will appear on the far left side of the map around a space station. In subsequent game rounds, they appear from the last selected planet, revealing any neighboring planets.

Phase 2: Outcome of the vote
An indicator flashes across the available planets, building anticipation before the result of the vote is revealed. The planet that was chosen by the majority of students becomes highlighted. In case of a tie, the planet is chosen randomly from the top choices. The three player ships teleport away from their current location and appear at the new location, where they land on the planet.

Phase 3: Ask questions
The game transitions from the map view to a view of the planet. Each planet has a different aesthetic and inhabitant, with seven unique options. The planet appears desaturated in color, and the *Haze* surrounds the inhabitant. The inhabitant welcomes the player in a lethargic manner. They suggest that the players ask them questions about the planet's sub-topic to spark their curiosity again. Students are then provided with an interface through which they can type in questions to ask as many interesting questions relating to the sub-topic as possible within the time limit.

Phase 4: Question review
While the teacher evaluates the incoming questions, students are shown questions posed by the class that the teacher has already accepted. Each question also shows the author for other students to see.

Phase 5: Round results
Students see the planet view and the inhabitant again. With their curiosity restored, the inhabitant is no longer affected by the *Haze* and the planet itself has been revitalized. The inhabitant thanks the students and shares some information based on the sub-topic. Depending on the cumulative number of accepted questions from a particular team, the inhabitant is shown to be very happy or somewhat neutral. The information the students receive is the same regardless.

The game continues in rounds following these phases until the endgame is triggered. This can happen in two ways. First, the students may vote to end the game in phase 1.

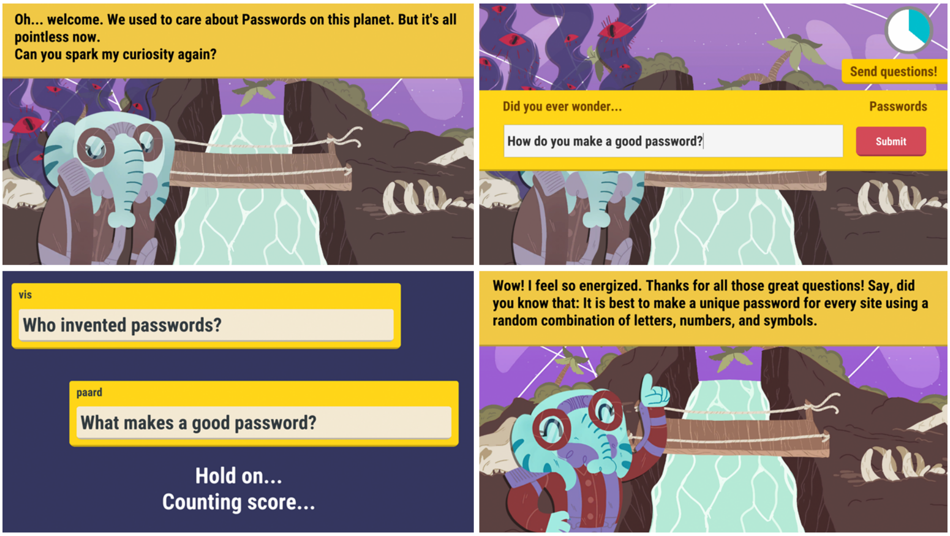


Figure 3.6: Screenshots showing the game phases for students after landing on a planet.

This requires them to uncover enough of the map to reveal the endgame node, visualized by another space station. Second, the teacher may trigger the endgame in phase 1, regardless of whether the endgame node was voted on or was even available to students. The endgame is split into the following phases.

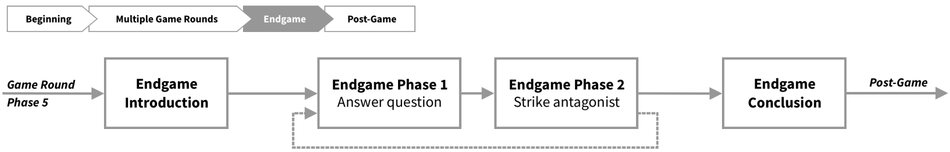


Figure 3.7: Flowchart of the endgame phases.

Endgame Introduction

The player ships travel to the final node on the map, and the game pans towards the right to reveal the *Haze*. From here, the final confrontation begins.

Endgame Phase 1: Answer question

The students are posed a question by the *Haze*. The question will relate to one of the sub-topics they visited, and the correct answer is the bit of information they learned from the inhabitant they helped. This aspect of *CURIO* aims to check whether students paid attention during the sessions and absorbed the information.

Endgame Phase 2: Strike antagonist

Depending on how the students answered the multiple-choice question, each team shoots a rocket at the *Haze*. If a majority of the students in a team answered correctly, the rocket is visually larger. The game repeats endgame phases 1 and 2 until the students answer three questions. If less than three sub-topics were visited, the phases would only repeat for that amount. Once the students answer enough questions, the game moves on to the endgame conclusion.

Endgame Conclusion

An animation shows the player ships defeating the *Haze* successfully, bringing the game to a satisfying conclusion.

Post-Game Activity: Decorate ship

Students earn points throughout the game session by asking questions and answering the multiple-choice questions correctly in the endgame. Students use the points in this last activity of the game. A large version of the team spaceship appears on the screen, which students can decorate with virtual stickers using their points. All students decorate the ship together, meaning they will see each other's stickers as they place them. This concludes the game session with a small reward for the students. The final picture of the ship can be saved as a screen capture as a memento of the game session.

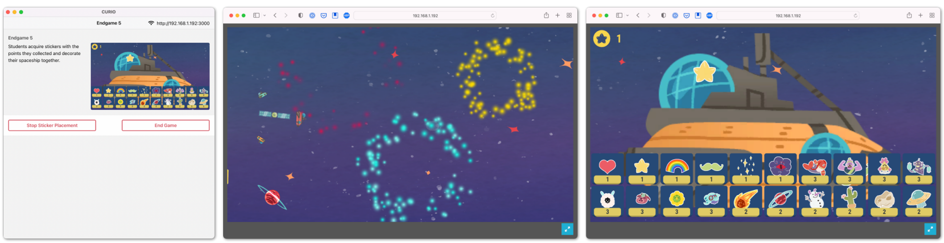


Figure 3.8: End of the game for students: decorating the ship with stickers

3.3.3 Teacher Side

While students play the game, teachers act as the “game master”. The teacher’s involvement starts with preparing the scenario for a game session. The teacher can open their side of the *CURIO* application to manage classroom and scenario files.

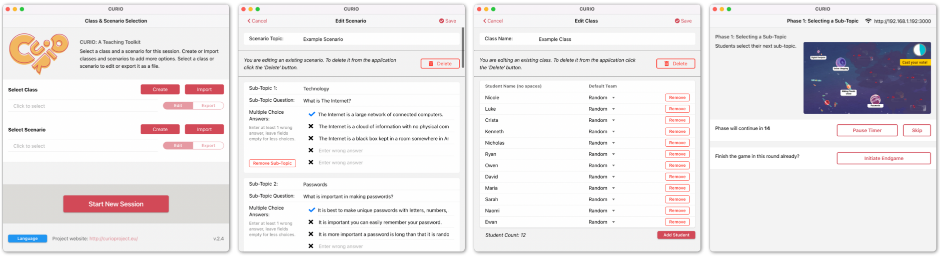


Figure 3.9: Screenshots showing the teacher interface.

Classroom file

The classroom file holds the login name of all students in a class. Students log in using their name at the game session’s start. The teacher can, therefore, know who asked particular questions or how individual students answered the multiple-choice questions in the endgame.

Scenario file

Scenario files hold the information for a particular scenario. The teacher sets an overarching topic for a game scenario (e.g., “The Internet”, “Physics”, “Algebra”). They then define sub-topics (e.g., “Online shopping”, “Passwords”, “Digital footprint”) with a minimum of one sub-topic. The teacher provides an exam question for each sub-topic and the answer to that question. The students can encounter these questions in their final confrontation with the *Haze*. They can also discover the correct answer to the question if they visit the planet corresponding to the sub-topic during the session. Because of how the planet inhabitant conveys the information, it is ideal if the answer forms a standalone sentence. The teacher also provides between one and four wrong answers to the question that appear as part of the multiple-choice interface.

The teacher selects a created classroom and scenario file from the main menu. With both selected, they can start a game session. Teachers then see a list of the names in the classroom file. From this point on, students can connect to the teacher's IP address using their own devices and log in to the game using a name in the classroom file. The teacher sees a student's status change in the list when they log in and their team (red, blue, or yellow). Team sorting is random initially, with students being distributed across the three teams equally as they log in. The teacher can overwrite the sorting manually to establish groups.

Once all students have logged in, the teacher starts the game. From this point on, the teacher application follows the same phases as the student application. Some phases are timer-based and will advance automatically, while others will only do so when the teacher initiates the next phase. The interface shows the phase the game is in, as well as a short description of that phase. A screenshot from one of the running student applications is periodically sent to the teacher application (every 5 seconds) to inform the teacher of what students see at that moment on their screens. The following sections describe the phases that require specific input from the teacher. Any other phases are timer-based by default and will advance without interaction. Any phase can be advanced before the timer runs out or can be paused by the teacher.

Phase 1: Vote for target location
There is no specific interaction required from the teacher, but they can decide to initiate the endgame early in this phase. The application will ask for confirmation before triggering the endgame. Selecting this option will override the vote of the students for this round. Instead, the ships advance to the confrontation with the *Haze* in phase 2.

Phase 3 and 4: Evaluate questions
Questions asked by the students will appear in the teacher application. The teacher can choose to accept or reject a question. Each student and their team will earn a point for each accepted question. The questions appear in batches. Once the teacher processes all available questions, questions submitted in the meantime appear next. This process repeats until no more questions are left to assess. Phase 3 will advance automatically for the students after a set timer, while phase 4 will remain active until the teacher has assessed all the questions and decides to move on to the next phase. Phase 4 is the most suitable moment to pause the game session for a longer time and discuss some of the questions submitted in that round.

The phases repeat until the students or the teacher triggers the endgame. The game requires no additional input from the teacher once the endgame begins but can be paused by them at any point. Students answer the multiple-choice questions and defeat the *Haze*, after which they decorate their ship. The teacher can decide when to end the game session for everyone by closing the teacher application. This automatically also closes the game for all students.

CURIO saves the submitted (and accepted) questions for each session, including which student asked each question. This information is available to teachers and can help plan upcoming lessons or have further discussions and activities in class about the topic that the game session covered.

3.3.4 Technology

While the design of the *CURIO* gamekit consists of two components (teacher and student side), the application runs as a single executable on the computer of the teacher (supporting Windows, Mac, and Linux). The executable, created using the *Electron* software framework (OpenJS Foundation 2019), opens the teacher interface and starts a local server in the background. The server hosts a WebGL application, created using the *Unity* game engine (Unity Technologies 2018) that students access by connecting to the server's IP address (prominently displayed in the teacher interface) via any internet browser capable of displaying WebGL content. Teachers can also change their computer network name so that the server is reachable by using a more memorable address, such as ***`http://curiogame.local`*** or similar.

Students can use laptops, desktop computers, or mobile devices to load the WebGL application, thus allowing for a variety of different devices and operating systems. Since the teacher hosts the WebGL application on their computer, student devices need to connect to the same local network as the teacher's computer. None of the machines require access to the Internet — once students access the WebGL application, their browser connects to the teacher interface via the local server for any communication about game states. As long as the teacher keeps their interface open, the game is accessible to students. By closing the teacher interface, the server is shut down as well, thus making the student side of the application unavailable. The student side detects this and informs students that the game has been closed.

The student side application can also run as a native *Android* or *iOS* application, which requires installation on each device. In this case, students do not use a browser. Instead, they use the native application to connect to the server on the teacher's computer. Students enter the IP address or computer name address of the teacher's computer into the native application to connect to the server. Otherwise, the game functions the same as the browser version.

All data in *CURIO* is created on the teacher's computer and accessed from there. The teacher application stores all scenarios and gameplay data in a local database in the application folder. Teachers can export created scenarios and class lists for backup purposes or to share them with colleagues. Any identification of individual students is limited to the name that teachers give them within a class list. They can use the first name of a student or a nickname that students choose for themselves.

3.4 Evaluation Study

The involvement of the development team (and the author of this thesis) in the *CURIO* project was set to end before the game would be made available to Maltese schools. Toward the end of the project timeframe, an evaluation study was conducted with 25 students at a Dutch primary school. In this study, students used a functional version of the *CURIO* gamekit. At the point of testing, the game did not yet include all final game assets (i.e., some game graphics were still a work in progress). The previously described end-game and post-game activity had also not yet been implemented. However, the game was sufficiently completed to test its core mechanic (i.e., asking and discussing questions) in a classroom setting.

The study's goal was to gather feedback from the teacher and students after playing the game. Measures included observational notes, a lightly structured (group) interview of the students, an interview with the class teacher, and a child-friendly game experience questionnaire; the Extended Short Feedback Questionnaire (eSFQ) from Moser et al. (2012).

Figure 3.10: Overview of the evaluation study environment.

3.4.1 Procedure

The experimenters met with the teacher to discuss the testing procedure before the session. The experimenters then tested the reliability of the wireless network and went through all steps of *CURIO* to ensure its functionality.

The teacher introduced the experimenters to the class. In addition to providing a supporting role, they could monitor the students' devices from their computers during the session. One of the experimenters fulfilled the role of the teacher during the test session, while the second took observational notes. The teaching experimenter explained the test's purpose and mentioned to students that their feedback could improve the game for others who would use the application in the future.

The teacher formed groups of students instead of each student participating with an individual device. Instead of using 25 devices, groups of 4-5 students shared a total of 6 *Chromebooks*. Rather than identifying each player by name, teams could choose animal names: fox, rabbit, frog, snake, fish, and hedgehog. A group was thus referred to as, for example, player "fox". Due to a technical issue, these six groups were distributed unevenly over the three in-game teams, leading to unequal distributions in team sizes.

After the experimenter ensured that students had no remaining questions about the test procedure, they presented the topic of the game session: The Internet. The experimenters chose this topic in advance with the teacher, which students were likely familiar with, but had not discussed in depth. Students played three rounds in which they chose sub-topics related to the session topic. The topics chosen by popular vote within the game kit were: "technology", "making friends online", and "online shopping".

A short discussion followed each game round, during which the experimenter highlighted some questions students had provided. The questions formed a starting point to assess what students already knew about the sub-topic and trigger further consideration. The experimenter paired such inquiries with new information that students might not yet be aware of. In each case, the discussion was kept short as the allotted time before the end of class was limited. In a normal teaching situation, teachers would likely be able to schedule their time differently and continue for longer, depending on what inquiries are formed by the students.

After the game session concluded, the experimenter asked students for their opinion on the game, focusing on feedback that could improve it. This exchange was followed by handing out anonymous single-sheet questionnaire forms — the eSFQ mentioned in section 3.4 — to gather individual feedback. The teacher took over once students completed the forms, discussed some school-related matters, and ended class. The experimenters then discussed the test session with the teacher and took notes of what the teacher thought about the gamekit and its functionality.

3.4.2 Results and Interpretation

The active part of the user test session (that is, playing the game, excluding prior explanations) lasted roughly 30 minutes. All participating students filled in the eSFQ (***n=25***). Students ranged from ages ***8-10*** (***Mn=9.4***, ***SD=0.6***). The gender distribution was ***16*** female students (***64%***) and ***9*** male students (***36%***).

Enjoyment (measured in the eSFQ by filling in a thermometer depicting increasingly happy emojis and scaled 1-5) was on average rated ***3.9*** (***SD=0.9***). When asked whether they would want to play the game again, ***18*** marked “Yes” (***72%***), ***5*** marked “Maybe” (***20%***), and ***2*** marked “No” (***8%***).

The three Likert-scale questions yielded the following results (rated from 1 to 5, with 5 indicating the highest agreement):

- “I wanted to continue playing to see more of the game” — ***Mn=3.9***, ***SD=1.1***
- “I was curious about what would happen in the game” — ***Mn=3.9***, ***SD=1.2***
- “I was looking for explanations for what I encountered in the game” — ***Mn=3.0***, ***SD=1.4***.

Ratings of the first two statements suggest that students were engaged and focused on the task. The third statement received mixed ratings. It is reasonable to assume that this is because the game does not present events that students can investigate further. Instead, students need to consider what could make a virtual character interested in a topic. It can be hypothesized that the overall narrative of the game (a *Haze of Confusion* affecting a galaxy) is only a mild trigger for investigating a given sub-topic. However, given that the narrative is primarily a framing device for the involved sub-topics, it is an acceptable shortcoming as long as the gamekit serves as a platform for shaping discussions within the classroom. In addition, the question being somewhat complex itself possibly contributed to the mixed results.

In terms of labels that were marked by students in the eSFQ, the three most frequently were: “Fun” (***80%***), “Easy” (***60%***), and “Great” (***40%***), while the three least used labels were “Boring” (***20%***), “Difficult” (***20%***), and “Childish” (***0%***).

When asked to mark labels regarding how it was to play the game with others, the three most picked labels were “Fun” (***80%***), “Satisfying” (***64%***), and “Cooperative” (***60%***), while the three least used labels were “Competitive” (***8%***), “Discouraging” (***4%***), and “Angry” (***0%***).

Based on observations from the test session, students were engaged in the game and invested in performing well. Students appeared to understand that performance was connected to asking many questions and the quality of such questions. This understanding was evident through the team discussions that emerged in the class and was also commented on by the teacher. It became evident that “something happening on-screen” was an important reminder for students to remain focused on the task. Students became noticeably louder during phases in which the game kit informed them to wait for the teacher to catch up on evaluating questions. Given that the teacher is occupied during this time, the game kit should provide support in the form of offering helpful information to students.

In the group discussion, students noted various reasons for enjoying the game. They enjoyed coming up with questions and cared about whether their questions would be discussed in class. The chosen topic was one that all students knew of but had never given much thought about. One student commented that asking questions made them think more deeply about the topic than they usually would. The student further noted that it made them realize that they knew more about it than they had initially thought. While students generally enjoyed working in teams, at least one younger student felt overshadowed by teammates claiming control of the device. Due to the technical mishap in uneven team distribution, some students perceived the competitive aspect as unfair. Overall, students did not mention competition as particularly positive, and it sooner had the potential of creating a hostile situation for the losing students.

The final discussion with the homeroom teacher highlighted the potential for the application, especially in modern teaching environments involving (mobile) computers. The teacher mentioned they would use a tool like *CURIO* in their teaching. In this particular school, the teaching method is shifting towards a project-based approach, in which groups of students formulate a research question and examine it for some weeks. The teacher noted that *CURIO* would be a good fit at the start of such a project to help students come up with questions to explore. They also preferred having students control the game individually rather than in teams so that each student could think of questions at their own pace. The teacher expressed interest in participating in future evaluations and was enthusiastic about *CURIO*'s goals.

3.4.3 Discussion

The evaluation study generated promising results. Response from the students was generally positive, and their feedback provided valuable input at that stage of the game's development. The students were engaged and focused during the game session. In addition, *CURIO* facilitated discussion between the students and appeared to stimulate thought on the presented topics.

The teacher's feedback suggests that *CURIO* is a good fit for new educational approaches in the Netherlands that focus on experiential learning. The quality of the questions asked by the students increased over time, indicating that it is best to use the *CURIO* gamekit for at least half an hour. Repeated use of the gamekit may also contribute to students learning to ask more complicated questions. The initial test suggests that *CURIO* can meet its primary goals at its inception. It can be a helpful tool for teachers in structuring conversation around a new topic, stimulating students to take on an inquisitive mindset around a topic, and giving teachers a better understanding of their students' prior knowledge and assumptions.

While these initial results are positive, further validation of a concept like *CURIO* is necessary to assess its usefulness to teachers and students. The final version of the game kit requires testing in different schools that follow various teaching methods. Depending on the environment, *CURIO* may not fit well with different teaching styles.

It is also essential to understand the *CURIO* game kit in the way it has been intended: as a tool that teachers can use to support their teaching efforts, using infrastructure that they have at their disposal. The school where the evaluation study took place was chosen partly due to its existing integration of technology in the classroom. This setup is what many schools aspire to, as is evident by "one tablet/laptop per child" initiatives. However, this technological infrastructure is far from the standard in all schools.

It was a welcome find that *CURIO* appears to fit well with the teaching methods employed at the school where the evaluation study took place. However, different schools and teachers may provide varying opinions on *CURIO's* usefulness to them. The *CURIO* game kit does not propose that technology in the classroom intrinsically improves the quality of education but instead aims to provide valuable content for classrooms that utilize technology to support teachers and students. Teachers that categorically dismiss the use of game-based technology will find as little use for the gamekit as those that expect it to provide educational value without their involvement.

The results of the evaluation study inspired several more changes to the game kit. The number of default sub-topics per game session was reduced to limit the overall game length. Teachers were also given more control over certain aspects (e.g., team composition and session length), and students were given increased interactivity options when the teacher evaluated student questions. A brainstorm session with the students resulted in the endgame and post-game activities, described in section 3.3, which provide a natural conclusion to the session. These additions tone down the competitive aspect, and students receive individual rewards for their questions. Several additional minor changes included adjustments to timing and visual feedback to clarify what students can do at a given moment in *CURIO*.

3.5 Using CURIO in class

This section presents guidelines for using *CURIO* in the classroom based on the results of the evaluation study and the design intentions behind the application. Notably, these come with the caveat of putting interested educators in the position of testing out a new tool. Nevertheless, they should be considered the best available evidence for how *CURIO* can support teaching. Apart from aiding educators, these guidelines can support developing and researching other GBL projects intended for similar circumstances and environments.

I. Game Flow: Ideally, each game round in a *CURIO* session is followed by a discussion between the teacher and students. The teacher can refer to inquiries made to explain aspects of the related topic. Especially in large classes, it can make sense to address the most frequently occurring questions and ask students to argue for what answers might be possible and why. *CURIO* makes it easy to extend or skip individual phases in a game round as teachers see fit. Teachers are encouraged to use that functionality to support their teaching efforts.

II. Timing and Time Investment: The *CURIO* game kit is best suited for introducing new topics where teachers can expect to find some pieces of pre-existing knowledge among their students. Topics that are radically unfamiliar to students might lead to the formulation of fewer, too general questions. On the other hand, topics that are very specific or well-understood might lead to questions that are less likely to be actually on the mind of students. Sessions involving *CURIO* should not occur too frequently, as the process of formulating questions is mentally exhausting and should be followed by actually addressing some of the posed inquiries. Teachers should also not rush through a session but rather implement breaks as teaching and playing are interdependent activities when using *CURIO*. Teachers should schedule 1-2 hours for their first session with *CURIO* and should make sure that students can anticipate the ending if a session ends before exploring the entirety of the game board.

III. Managing Expectations: *CURIO* should not be framed as a reward in itself and should not be used as such by teachers. While it features elements that are intended to feel rewarding, it is an activity that demands time and concentration from both students and teachers. This demand makes it a poor choice for concluding an already intensive teaching day. Teachers will need to be open to the possibility of using games as a legitimate medium for education and not solely as a source of entertainment. This also means leaving enough time for the conclusion of the game, where students get to collectively defeat the game's symbolic antagonist and decorate their ship as a reward.

IV. Preparation: While care has been taken to keep organizational tasks in the game as simple as possible, teachers are advised to prepare their session with *CURIO* in advance. A well-prepared scenario will give teachers a better idea about what to discuss between the individual game rounds and ensure that the questions that students come up with are relevant to what is supposed to be covered by the curriculum. Class lists are also best created before a session takes place. For the very first session, teachers will also have to explain how students connect to the teacher's computer.

V. Openness to Questions: *CURIO* gives teachers complete control over what they deem good questions. During early focus groups, teachers remarked that the phrasing of "rejecting" a question sounded harsh. While students are not directly informed about having their inquiries rejected, the blunt language for not accepting a question is by design. Teachers are invited to be generous about what is a good question, as the process of coming up with questions is demanding. Whether or not to discuss a question in class remains up to the teacher's discretion. Rejection of inquiries is intended as a measure reserved for inappropriate behavior rather than an evaluation of student performance.

3.6 Conclusion

The main research question guiding this chapter was: How can a game facilitate conceptual exploration? It then explored this question through a design case study of a game-based learning application, the *CURIO* gamekit.

Existing game-based learning tools generally focus on imparting and testing content-specific knowledge. Secondly, they often exclude the teacher from the play experience. *CURIO* addresses these issues by involving teachers as active participants, helping to structure discussions around a new topic, and gathering data for teachers to shape upcoming classes.

For the context of this chapter, however, *CURIO*'s most important contribution is that it encourages students to adopt an inquisitive mindset. It does so by leveraging existing technology in classrooms while allowing for various technological solutions that do not require specific hardware or external infrastructures (e.g., an Internet connection).

Results of the evaluation study suggest that the design of *CURIO* can support teaching efforts in the classroom *(answering RQ1)*. It also indicates that students become more curious about the game's topics *(answering RQ2)*.

It should be noted that the study did not test whether it was more effective than involving non-game teaching material. Further evaluation is also required to show whether *CURIO* assists teachers and students in tackling a new topic. Future efforts, for instance, may involve using *CURIO* at the start of a project and evaluating students' behavior over an extended period. Similarly, further examination will need to show whether *CURIO* is considered helpful by teachers of different backgrounds and educational settings (e.g., varying by school and country). Answering these questions was outside the scope of this chapter, and the author's involvement with the project ended once the development and evaluation study had concluded. Upon finishing the project, discussions were taking place with the Malta Ministry of Education about integrating *CURIO* in classrooms.

The chapter illustrates how a game can be created focused on a particular type of curiosity, i.e., conceptual curiosity. It also shows that this is a complicated task even when focusing on a particular type of curiosity with a clear behavioral expression (i.e., asking questions, as derived from focus groups with teachers). It requires careful managing of the "information gap"; ensuring that there is enough information to stimulate thought but not so much as to take away all sense of wonder. In *CURIO*, this task is primarily delegated to the teacher as the "game master" who provides topics and leads intermittent discussions. If such considerations were not left to the teacher, they would fall to the game and/or content designer of the GBL artifact instead. Additionally, multiple other forms of curiosity also entered the design space, as explained in section 3.2.2, to increase the chances of eliciting the players' curiosity.

CURIO forms an example case study that shows, plainly and transparently, how a game can function to elicit conceptual curiosity, thus answering the research question. In addition to being a potentially beneficial GBL application, *CURIO* may also be used as a tool to further examine the balance required in structuring information to make optimal use of the “knowledge gap” by performing additional studies with different scenarios. Another contribution of this chapter is in describing the development complexities of a GBL artifact, a topic that will be further explored in Chapter 8. Most importantly, it shows how developing for a single, specific type of curiosity is a complex task, even in a relatively simple game, and one that involves design decisions aimed at triggering various forms of curiosity. In order to better understand various forms of curiosity and how they are elicited through game design, it is thus beneficial to take a broader perspective on video games and their design, as will be shown in the following chapter.

4 Video Games That Elicit Curiosity

Prior work discussed in Chapter 2 has illustrated promising links between curiosity and the playing of games. The previous chapter examined one form of curiosity (i.e., conceptual) through a case study. However, more forms of curiosity exist and, as of yet, it is unclear how these various forms may be elicited through gameplay or how differently designed games succeed in stimulating curiosity and encouraging exploration. Thus, it is beneficial to take a broader perspective, moving from a single case to the wider landscape of video games, and examine how they elicit curiosity and exploration.

> The research question that guides the work in this chapter is:
> **What types of games elicit exploration?**

This chapter describes the setup, execution, and findings of a study designed to *identify game titles and genres that elicit curiosity in video game players*. In addition, it inquires whether there is a *relation between the games that makes players curious and personality-based curiosity traits*. No published work was found addressing these points before this study.

In the study, data is collected from a wide range of video game players about their subjective experience of curiosity with games they have played in the past. Participants are asked to rank games they have played from a list of 15 pre-selected game titles in order of how curious the game made them feel. They are also asked to suggest and rank additional game titles based on different dimensions of curiosity. The study follows the Five-Dimensional Curiosity Scale (5DC) proposed by Kashdan et al. (2018) and investigates links between the individual dimensions and specific games or genres. Besides this, it identifies correlations between games and curiosity dimensions that are the subject of recent psychological studies (Grossnickle 2016; Reio Jr. et al. 2006).

The rationale for exploring such links is that what triggers curiosity in players might depend on their personality traits; on long-term inclinations regarding what elicits their curiosity. While some games might involve multiple design strategies to stimulate curiosity on different dimensions, such as providing interesting landscapes to explore and intricate puzzles to solve, other games might appeal more narrowly to individual curiosity dimensions.

Participants in the study are not asked to apply a specific definition of curiosity or what does or does not constitute a video game. As a result, the study captures a range of subjective associations of the experience of curiosity in video games. Furthermore, given that video games can invoke curiosity in different ways, the study aims to identify consensus and patterns among video game players rather than specific strategies for eliciting curiosity.

The study is designed to answer three research questions (RQs):

1. What games and genres elicit curiosity as part of their gameplay?
2. Do individual differences in trait curiosity dimensions impact what games and genres make a player curious?
3. Does age or gender impact what games or genres elicit curiosity?

The most important outcome of the study is the systematic and informed selection of games and genres that elicit curiosity, described in detail in section 4.4.1 (addressing RQ1). Statistical assessments of the study results do not show strong evidence for an impact of curiosity dimensions on what games and genres elicit curiosity. Some significant correlations were found, e.g., the extent to which role-playing games stimulate curiosity, and are discussed later in section 4.4.2. Overall, however, the study's results do not provide sufficient evidence to answer whether trait curiosity dimensions systemically impact what games and genres elicit curiosity (addressing RQ2). The survey results show that male players are more likely to be curious about *Strategy* and *Task Simulation* games than female players. Players are found to be more curious within *Puzzle* games with increased age (addressing RQ3). The study does not find evidence for different appraisals of individual game titles based on players' age or gender.

The following section describes the method of the study, including the psychometric instrument used to establish curiosity dimensions, and how rankings are established between game titles that are not played by all participants in the study. This is followed by a description of the study procedure and results. The end of the chapter discusses the findings of the study and their implications for further research about eliciting curiosity through video games.

Chapter Publications

Work presented in this chapter has been published in these peer-reviewed venues:

- **International Conference on Entertainment Computing (ICEC Conference) – 2018**
  "Games that Make Curious: An Exploratory Survey into Digital Games that Invoke Curiosity" (M. Gómez-Maureira and Kniestedt 2018)
- **Entertainment Computing (ENTCOM Journal, Volume 32) – 2019**
  "Exploring video games that invoke curiosity" (M. A. Gómez-Maureira and Kniestedt 2019)

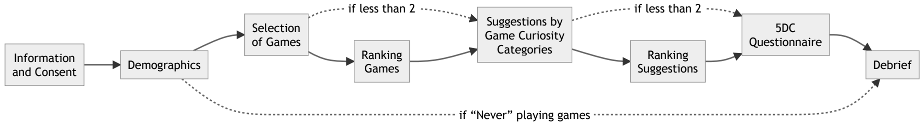
4.1 Materials and Methods

The study uses an online survey format to reach many participants with diverse backgrounds. The survey is specifically aimed at people who have played video games in the past and who are comfortable reading and writing in English. Otherwise, the survey does not have any exclusion criteria. This section describes the individual survey steps and the rationale behind decisions made in the process.

The survey is conceptually separated into the modules: demographics, shared selection of games, suggestions by curiosity dimensions, and curiosity questionnaire.

Within the survey, the modules were presented over separate survey screens. The following subsections describe the individual survey modules and methods used to assess the results.

The survey flow can be seen in the following chart:



4.1.1 Demographics

The demographics module comprises three questions: age, gender, and frequency of playing games.

Data on age and gender are collected to consider whether either impact what game genres elicit curiosity and assess the distribution of the study sample. Psychology research by Giambra et al. (1992) suggests that the need to seek information is not impacted by age, but the need to seek stimulation (i.e., alleviating boredom) is; decreasing with age. They further found differences in genders, with women showing "an increase in impersonal-mechanical curiosity and a decline in interpersonal curiosity" with increased age. In contrast, no such change was found in men. Considering this, there is some evidence that age and gender could have an impact that needs to be logged to analyze the study results.

Furthermore, while this study does not target a specific age range or gender, the sample of the population participating in the survey might be skewed compared to the general (game-playing) population. Data on participants' age and gender thus indicate whether results can generalize to a broader population or whether caveats need to be considered.

Participants are prompted to provide their age as "year of birth" and their gender by selecting between female and male or entering their gender identification as free-text. A question on playing frequency acts as an exclusion criterium, ending the survey for all participants that do not play video games. It also provides data to assess whether general play frequency impacts what games elicit curiosity in players. Participants are prompted with the statement "I typically play computer or video games …" that they complete by choosing one of five answers: *Every day*, *Every week*, *Occasionally*, *Rarely*, or *Never*. Choosing *Never* excludes participants from reaching subsequent survey modules and from being part of the study.

4.1.2 Selection of Games

In the second survey module, participants are presented with 15 critically acclaimed game titles and asked to select which of them they have played. The number was picked as a heuristic, balancing the need to involve a sufficiently large number of titles, increasing the chances of participants having played a few of them that they can then rank, and the need to keep participants from becoming overwhelmed by the amount. Especially participants who have played many games from the list would need to spend more time and energy establishing a ranking between the games.

The decision on which games should be included in the list is based on *recency* and *critical acclaim*. The threshold for recency is set to 10 years as an arbitrary threshold but chosen to keep games within the list relatively similar in terms of technical features and game complexity. To illustrate the need for a recency threshold: although *Pong* (Atari 1972) might have been a revolution when it was released, technical capabilities, audio-visual fidelity, and conceptual complexities have increased considerably since then. Ranking of games between different eras could make it more likely to involve nostalgia or recency bias rather than idiosyncratic properties of a game title. At the time of the study, this means only including games that were released between 2007 and 2017.

Critical acclaim is measured based on a game's *Metacritic* score (Metacritic.com 2018), selecting the 15 highest-rated games within the timeframe mentioned earlier (excluding entries from the same game series, as will be discussed below). The resulting selection involved games with a *Metacritic* score of 94 or higher (out of 100). *Metacritic* scores are based on the average scores that are given by a select list of game journalists and critics. Within the video game industry, *Metacritic* scores are often considered a measure of a game's artistic quality and even shape development expectations and hiring practices (GameDeveloper.com 2012). While a high *Metacritic* score is not always predictive of popularity and financial success, there is evidence of a strong correlation (Greenwood-Ericksen, Poorman, and Papp 2013). As such, it is a reasonable proxy measure to establish game titles that are both widely known and known for high production quality. This should make it more likely for participants to have played games on the list and experienced curiosity as part of their experience.

While the selection of games list counts 15 entries, the number of games reflected in it is higher because multiple games within a game series are grouped under a single entry. A *game series* is defined by a shared cast of game characters, a somewhat consistent audio-visual aesthetic, related narrative arcs, and many similar game mechanics, and typically refers to prior entries in some way as part of the title. The decision to group games from a series into a single entry was taken to involve a diverse selection of different games while keeping ranking easy to understand for participants. For example, participants might have played only some titles in a game series that are, however, sufficiently similar to one another for the context of the study. Grouped entries do not stand for all game titles within a series but are limited to those that fit the selection criterium outlined before, i.e., released within the same 10-year timeframe and with similarly high *Metacritic* scores. As such, some entries in the list stand for a single game, while others include a range of game titles. Overall, the 15 entries in the list implicitly include 27 individual game titles (table 4.1).

Table 4.1: List of game selection with corresponding implicitly included game titles (prompted by "Select which of the following games you have played …")

List Entries	**Implicitly Included Game Titles**
Grand Theft Auto IV (or newer)	*Grand Theft Auto IV* (2008) and *Grand Theft Auto V* (2013)
The Legend of Zelda: Breath of the Wild	Single title, as mentioned (2017)
Super Mario Galaxy or Super Mario Odyssey	*Super Mario Galaxy* (2007) and *Super Mario Odyssey* (2017)
Batman: Arkham City (or Asylum)	*Batman: Arkham Asylum* (2009) and *Batman: Arkham City* (2011)
The Elder Scrolls V: Skyrim	Single title, as mentioned (2011)
Mass Effect (any in the series)	*Mass Effect* (2007), *Mass Effect 2* (2010), and *Mass Effect 3* (2012)
Uncharted (any in the series)	*Uncharted: Drake's Fortune* (2007), *Uncharted 2: Among Thieves* (2009), *Uncharted 3: Drake's Deception* (2011), *Uncharted 4: A Thief's End* (2016)

List Entries	**Implicitly Included Game Titles**
BioShock (any in the series)	*BioShock* (2007), *BioShock 2* (2010), and *BioShock Infinite* (2013)
Metal Gear Solid V	*Metal Gear Solid V: The Phantom Pain* (2015)
The Last of Us	Single title, as mentioned (2013)
Portal (or Portal 2)	*Portal* (2007) and *Portal 2* (2011)
Red Dead Redemption	Single title, as mentioned (2010)
LittleBigPlanet (or LittleBigPlanet 2)	*LittleBigPlanet* (2008) and *LittleBigPlanet 2* (2011)
Call of Duty: Modern Warfare (or Modern Warfare 2)	*Call of Duty 4: Modern Warfare* (2007) and *Call of Duty: Modern Warfare 2* (2009)
Street Fighter IV	Single title, as mentioned (2008)

4.1.3 Ranking Games

After selecting games, participants are presented with the sub-selection of games they have played in the past. Participants are prompted to "Rank the games in order of how much they triggered your curiosity while playing them (most curious on top) – leave out games that did not make you curious at all while playing." With these instructions, the list of ranked game titles is expected to be not only fewer than 15 (given that few participants will have played all games on the list) but also fewer than all titles they have played, as they can choose not to include titles that have not elicited much curiosity.

It should be noted that the study emphasizes curiosity as part of the gameplay rather than how curious participants might have been to play a game title before doing so. This emphasis is reflected in the phrasing of the prompts in the study.

Asking participants to rank rather than score game titles, for example, on a Likert scale, regarding the curiosity that was experienced brings some benefits. For one, the task is easily explained and requires less time. Furthermore, reporting about affective constructs is challenging, and applying a rating consistently can be particularly difficult (Yannakakis and Martínez 2015). Ranking allows participants to use individual game titles as points of reference instead, thereby not having to make assumptions about the meaning of choosing, for example, 4 out of 10 on a curiosity scale.

However, ranking introduces some challenges that would not be present with Likert scale ratings. Ranking does not provide the possibility to capture quantitative information. Two game titles might be very close in their impact on a participant or very far apart; the collected data would not provide any evidence as to which is the case. Participants are also forced to rank titles they consider similar regarding experienced curiosity, as they cannot give two titles the same rank. Another challenge comes from the analysis of ranked game titles when not all titles are ranked, and the amount of ranked items is not the same across participants. Not all people play the same game titles. Likewise, participants may rank varying numbers of games, either because they do not play as many games or because they do not consider them to be invoking curiosity.

These challenges are likely, at least in part, reasons for why ratings remain part of many studies to assess affective constructs, despite the criticism that can be leveled against their use. For this study, the benefits of ranking game titles are considered to outweigh the drawbacks. Forced rankings of titles that elicit curiosity equally well should normalize across a large sample size. For the most significant challenge, evaluating rankings across participants, the study took inspiration from a similar challenge in game ranking systems where assessing player strength results from multiple, usually unequal amounts of games played. The following sub-section discusses ranking analysis in more detail.

4.1.4 True Skill Rank Analysis

Ranked results in the study are analyzed using the *TrueSkill* rating system, developed by *Microsoft* for ranking and match-making of players on their *Xbox LIVE* online platform (Herbrich, Minka, and Graepel 2007).

One challenge ranking systems in multiplayer games face is determining the relative strength of players in zero-sum competitions. Simply counting the number of wins neglects the context of how those wins were achieved. A player might have played only against relatively inexperienced opponents and thus notched a high track record that does not reflect their skill level. It should be evident that a hypothetical newcomer playing and winning against a world champion should rank higher than a simple tally of successes would indicate. Multiple rating systems have been developed to assess the relative strengths of players. Examples include *Elo*, created to rate the performance of chess players (Elo 1978), *Glicko* (Glickman 1999), and *TrueSkill*, which has also been used outside of games in education (Kawatsu, Hubal, and Marinier 2018) and to improve recommendation systems (Quispe and Ochoa Luna 2015). Recent work carried out after the present study has been completed suggests broadly similar accuracy between these rating systems, especially with increasing match-up data points (Dehpanah et al. 2021).

TrueSkill uses a *Bayesian inference algorithm* that updates the score of individual match items (usually representing the skill of players) every time a match is played. Since score points can be lost, participating in a high number of matches does not necessarily result in a higher ranking.

Conceptually, the analysis of ranked game titles in this study is approached as if it were a competition between 15 players. Each game title represents a player that competes against other players, i.e., game titles. For each participant in the study, each ranked game title competes against all other ranked game titles. If a title is ranked higher, the title "wins" and thus increases its *TrueSkill* rating, while the "opponent" has its rating reduced. The higher a title is ranked in curiosity, the more wins it accumulates against other opponents.

After matching up all possible combinations across all participants, the resulting score is a measure of both the rank of a game title and the relative distance to other game titles. While the resulting score is an arbitrary number, it can be used in relation to other scores. Items with relatively similar scores can then be considered closer to equal, while those that differ by wide margins are likely to have won many comparisons.

In addition to analyzing rankings from the pre-established game selection, the same method is used for game titles that participants suggest. Here, participants can suggest up to ten game titles that made them curious and are then asked to rank them. *TrueSkill* scores are calculated for game titles suggested by participants (section 4.1.6) and for game genres that these games are part of (section 4.1.7).

4.1.5 Five-Dimensional Curiosity Scale (5DC) Questionnaire

The 5DC questionnaire, developed by Kashdan et al. (2018), is used to determine the distinctive "trait curiosity" of each participant. Trait curiosity describes the general tendency to be curious rather than whether or not a person is in a curious state (i.e., is currently curious or not). The individual dimensions outlined in the 5DC describe what stimuli (or lack thereof) are most likely eliciting a curious state. Whereas some people are most motivated by the desire to experience novelty, others might be driven by a desire to mitigate a lack of information.

More specifically, the 5DC consists of the following five dimensions:

1. **Joyous Exploration** (JE) — being motivated by novelty
2. **Deprivation Sensitivity** (DS) — experiencing a need to resolve
3. **Stress Tolerance** (ST) — the ability to cope with uncertainty
4. **Social Curiosity** (SC) — wanting to know about others
5. **Thrill Seeking** (TS) — enjoyment of anxiety

The questionnaire has been developed by selecting items of existing measures that evaluate interest and curiosity, openness to experience, need for cognition, boredom proneness, and sensation seeking. Individual questionnaire items were evaluated through three studies with a combined sample size of 3911 participants. The questionnaire was examined regarding test-retest reliability in a 4-month follow-up, with results within the range of stable personality traits.

The 5DC questionnaire consists of 25 statements for which participants indicate agreement on a 7-point Likert scale. The scale ranges from "Does not describe me at all" (1) to "Completely describes me" (7). The 25 statements are grouped into five scoring groups, corresponding to the individual curiosity dimensions, each of which includes five statements. The 5DC questionnaire results in scores for each dimension, calculated by the average score of statements within the scoring group (with items contributing to *Stress Tolerance* being reverse-scored).

The questionnaire is used at the end of the survey. It is discussed here, outside the chronological order of survey modules, to establish terminology used in describing other survey modules.

4.1.6 Suggestions by Game Curiosity Categories

After ranking among the 15 game titles selected for the survey, participants are asked to suggest additional game titles that fit the five curiosity dimensions of the 5DC (section 4.1.5). These suggestions are collected as free text responses and are not limited to a specific release year or other restrictions.

This survey step is meant to collect game titles that can be further analyzed for their ability to invoke curiosity, thus contributing to RQ1. By prompting for suggestions relating to each of the five curiosity dimensions, game titles that are suggested are implicitly grouped into *game curiosity categories* mirroring the respective curiosity dimensions.

Participants are asked to suggest up to two game titles for a total of up to 10 suggestions for each category. Categories for which to suggest games are phrased based on the 5DC questionnaire (table 4.2).

Table 4.2: Prompts used to group suggested game titles in five game curiosity categories.

Category Prompt “Video games that …”	**Category Label** (based on 5DC)
“let me **explore** or find out new things”	→ **GEXP** (based on *Joyous Exploration*)
“let me **solve** something”	→ **GSOL** (*Deprivation Sensitivity*)
“let me feel **safe** and stress-free”	→ **GSAF** (*Stress Tolerance*)
“let me understand or **connect** to people”	→ **GCON** (*Social Curiosity*)
“make me feel excited and **alive**”	→ **GALI** (*Thrill Seeking*)

In addition to suggesting game titles for each category, participants also rank their own suggested titles in order of how curious they felt while playing them, similar to the ranking discussed in section 4.1.3. Participants are asked to rank across all games (up to 10) they have suggested rather than per category. In contrast to the ranking of game titles provided by the study, the ranking of suggested game titles is assessed based on the game genres that the suggestions are part of. This is further described in the following sub-section.

4.1.7 Attribution of Game Genres

Game titles suggested by participants in the study are grouped by game genre. It can be expected that many suggestions are mentioned by only 1-2 participants and thus lack a broader consensus. This, however, is likely impacted by how well-known these games are. Even if these titles are ranked high in the curiosity they elicited, they would be part of too few conceptual match-ups to meaningfully increase their *TrueSkill* score (section 4.1.4). To derive useable information, suggested game titles are attributed to two game genres. The resulting grouping of games by their genres can then be assessed through *TrueSkill* scores.

The challenge in attributing game genres is the lack of a broadly shared definition of what constitutes a genre. Genre classifications can originate from multiple motivations, such as easing retrieval of titles, academic efforts to build a taxonomy or marketing considerations. Clarke et al. (2017) argue that genre definitions for video games are a combination of facets, such as gameplay, purpose, presentation, in-game point of view, or theme, to name a few examples. For example, the colloquially common genre of "action games" hints at fast-paced activity in a game but does not indicate a thematic setting or context. Taking control over a sports car in a game is generally a fast-paced activity but would be more commonly referred to as a "racing game".

Instead of following a specific genre definition, a list of 11 game genres has been devised to describe the most prevalent gameplay activities among suggested game titles. The list is based on commercially used genre labels but modified to be sufficiently general to stand for a range of different games. Instead of a shooter genre, which is typically defined by the competitive use of virtual guns, such a game is labeled as a *Reflex* game to indicate that success in the game is based on fast player reflexes. A racing game is instead labeled as a *Reflex* and *Task Sim* game, the latter of which indicates that players simulate tasks that are associated with a profession. This example also illustrates why game titles are attributed to 2 game genres, as video games frequently involve a combination of activities.

Many games that aim to entertain a large audience involve many activities for the player, optional or mandatory, to play a game to its conclusion. *Grand Theft Auto V* (Rockstar North 2013) lets players shoot virtual characters and race with cars but also allows them to ride a roller-coaster, attend virtual therapy sessions, or solve a murder mystery. In this example, the genres *Reflex* and *Exploration* are attributed to the game. The genres reflect that most activities in the game require fast reflexes and that a significant appeal of the game is in exploring the city and all activities that the game facilitates. While some nuance is lost by converting game titles into game genres, it allows for evaluating which activities in a game can be conducive to eliciting curiosity.

The game genres used in this study are based on collecting commonly used genre labels from online game stores and critic score aggregators. The list has been modified and condensed to a subset that is sufficiently general, descriptive, and independent of other labels. The final list is the result of argumentative discourse between the author and other game researchers and designers.

The following list outlines the genre labels, followed by a descriptor:

- **Reflex** — requires fast reflexes to perform well.
- **Exploration** — provides spatial or conceptual discovery that is not automatically brought to the player's attention.
- **Puzzle** — presents tasks that must be solved through predefined processes.
- **Strategy** — requires players to plan their actions, considering available resources.
- **RPG** — defined by assuming the role of one or more characters and making choices that impact game progression.
- **Story** — game progresses as part of a structured narrative.
- **Task Sim** — asks players to perform tasks associated with professions, emphasizing the nature of the task.
- **Social Sim** — asks players to perform actions associated with social interactions and everyday tasks.
- **Collecting** — is structured around gathering items to gather all or as many items as possible.
- **Frantic** — uses aesthetic elements, concurrent game mechanics, or both to saturate the cognitive capabilities of players.
- **Chance** — progress in the game is largely independent of the actions taken by the player but differs between game sessions.

It should be noted that the attribution of game genres to game titles is not dependent on how many activities a game features; all titles are given precisely two genre labels.

4.2 Procedure

This section describes the logistical details of conducting the survey and analyzing its results. The survey was conducted over one month and was completed by 117 participants. All responses were collected through the online survey system *Qualtrics* provided by the University.

Participants were recruited through *convenience sampling* and *referral sampling* within the University of the author, academic mailing lists, and online recruiting on *Facebook*, *Twitter*, and *Reddit*. The survey was also part of the survey exchange platform *SurveyTandem*, which promotes a survey in exchange for participation in the survey studies of other researchers. The target demographic included everyone who does or has played video games at some point in their lives. While the nationality of participants was not tracked, the most likely audience was English-speaking people in the Netherlands and, to a lesser extent, in western Europe and the United States.

The survey led participants through 8 modules split over multiple web pages, with the 5DC questionnaire module broken up over several pages to aid readability.

Apart from the modules described in *Materials and Methods* (section 4.1), the survey was prefaced by an information and consent module. On that page, participants were informed about the study's goal and the experimenters' contact information. To proceed, participants had to consent to have their responses recorded and stored on the University's *Qualtrics* server. The last module of the survey was a concluding debrief step that thanked participants for their time and repeated the contact information in case of further questions.

The survey flowchart shows that not all participants went through all modules. For one, participants who indicated that they do not play games were brought to the end of the survey, and their data was not used. The two modules asking participants to rank among previously selected or suggested game titles are only shown if there are titles to rank (i.e., when selecting two or more game titles).

4.2.1 Data Processing

After the survey concluded, the collected data had to be processed for further assessment. Incomplete responses were removed from the dataset.

Initial Ranking Calculation Initially, data processing of rankings was carried out without using the *TrueSkill* algorithm. It was only in assessing the collected data that a more specialized assessment method was sought. Initially, rankings were calculated by tallying how often a game title was played across all participants and using that number to adjust the weight in any ranking it was used in.

For each participant and game title, the following formula was used to calculate a title's curiosity score:

$$\text{curiosity score} = \frac{1 - \left(\frac{\text{rank}}{\text{rankcount}}\right) + \left(\frac{1}{\text{rankcount}}\right)}{\text{playcount}_{\text{all}}}$$

The formula weighs the score based on how many game titles a participant has ranked (rankcount), at which position it is ranked (rank), and how many participants have played the game ($\text{playcount}_{\text{all}}$). The score increases, the higher it is ranked, the fewer items a participant ranks, and the fewer participants have played the game title. The rationale for this weighing is that game titles played by many will be featured in more rankings and therefore accumulate a higher score based, at least in part, on popularity rather than curiosity. By using this formula, a game played by many will need to be consistently ranked high to end up with a high curiosity rank score.

The overall curiosity score of a game title is the sum of all scores calculated for each participant.

***TrueSkill* Calculation** For the ranking of selected games provided by the survey, *TrueSkill* ratings were calculated with the help of a Python package (Lee 2015). The 15 game titles had their *TrueSkill* rating initialized to be equal to one another. The script then iterated over all participant responses and, within each response, repeated over all unique pair-wise combinations of ranked game titles. For participants that had ranked among all 15 titles, this would result in 105 unique combinations and, therefore, 105 match-ups, with one game title winning over the other. The actual number of such matches depended on how many titles they ranked; in most cases, that number was lower. Roughly half of all participants ranked four game titles, which results in only six pair-wise matches for each. The total number of these matches was the sum of all participants that ranked at least two titles. For each match, the *TrueSkill* rating of both competing game titles was adjusted based on the match result. At the end of the process, each game title had a *TrueSkill* rating based on all participants' rankings.

Processing of Free Text Entries Before the *TrueSkill* calculation process could be repeated for game genres based on game titles suggested by participants, the entries had to be checked for duplicates and valid entries. Since game titles could be entered as free text, the resulting list could include different spellings of the same game titles. As a first step, a "fuzzy" text-matching Python package (SeatGeek 2017) was used to create a dictionary of unique entries. The algorithm uses the *Levenshtein distance*, a string metric that assesses the difference between two letter sequences, to calculate a percentage of how closely two strings match each other.

The algorithm identified text strings matching an existing entry with 70% accuracy (arbitrarily set based on experimenting with different values). Successful matches were grouped under a single title, while unsuccessful matches created a new title. All groupings made this way were logged and manually checked. The dictionary was manually expanded for any mismatched items, and the process was repeated until all "fuzzy" matched items were correctly grouped. The dictionary was manually checked for game titles that did not exist. Game titles that could not be identified through a subsequent web search were discarded from the dictionary.

As a next step, entries belonging to the same game series, or referring to the same game by another name, were combined into a single entry, e.g., *Oblivion* (Bethesda Game Studios 2006) was attributed to *Elder Scrolls*. The only exceptions were *The Legend of Zelda: Breath of the Wild* (Nintendo EPD 2017) — shortened to *Zelda:BotW* (distinct from *The Legend of Zelda* game series) and *World of Warcraft* (Blizzard Entertainment 2004) — shortened to *WoW* (distinct from the *Warcraft* game series). This process was carried out manually by consulting online resources such as game descriptions, reviews, and gameplay videos. The decision not to consider *Zelda:BotW* and *WoW* as regular entries in the rest of their respective game series is based on the assessment that these games are sufficiently distinct to warrant their own entries. In the case of *Zelda:BotW*, the game marked a transition to an open-world gameplay environment, whereas other games in the series are more linear. For *WoW*, despite sharing a similar name to other games in the *Warcraft* game series, *WoW* marked the transition from *real-time strategy* to what is known as a *massively multiplayer online game*. As a result, these exceptions were attributed to different game genres (as defined in section 4.1.7) than other entries in the respective game series.

Combining game titles of a series into a single item removes nuances that individual game titles might have brought to a game series. For the most part, however, games of a series intentionally share characteristics such as theming and gameplay. Making this decision allowed for assessing general patterns in game design, expressed through attributed game genres.

Processing of Game Genres After processing free text entries, the resulting list of game titles was converted to a look-up Python dictionary with corresponding game genres that could be used for further processing. Exactly two genres were attributed to each game title, choosing the most representative labels from a list of 11 genres (outlined in section 4.1.7). The first genre was chosen to be the most representative, with the second indicating the secondary genre. Genres were attributed independently by the author and one of their peers from the game research and design domain. Attributions were made based on personal familiarity with game titles and further desk research involving developer descriptions, reviews, and gameplay videos. Afterward, the two independently created dictionaries were compared for mismatches in choice of genres and their order. Mismatches were resolved item by item by discussing arguments between the author and the supporting peer until they reached an agreement.

Once the dictionary was completed, *TrueSkill* scores were calculated for all game genres. In contrast to the calculation for the selection of 15 game titles, scores for genres were based on a maximum of 10 suggestions per participant (up to 2 per curiosity category). This resulted in a maximum of 20 ranked genres (2 per game title), with individual genres being featured on multiple ranks (e.g., *Exploration* could be ranked 1st, 4th, and 8th simultaneously). Each genre instance was then matched against all other instances. In this case, the same genre pairing could lead to different winners since they would be representing different game titles. Matches between the same genres were not carried out.

Processing Game Curiosity Categories and 5DC Questionnaire A ranking of curiosity categories was calculated in addition to ranking game titles and genres. In this case, the ranking was established by replacing the ranked game title suggestion with the curiosity category for which the game title was entered. Similar to the ranking of game genres, each participant could implicitly rank a maximum of 10 curiosity categories, which would feature the same entries on up to two rank slots. For example, game titles entered under the prompt "Video games that let me *explore* or find out new things" (GEXP category) could be ranked 1st and 3rd, thus leading to GEXP being featured twice at different ranks.

Scores of the 5DC questionnaire were created for each participant by calculating the mean of Likert scale ratings of questions contributing to the corresponding five dimensions. Ratings were reverse scored for the *Stress Tolerance* (ST) dimension, as required by the questionnaire instructions.

4.3 Results

Out of 117 participants completing the survey, $N{=}113$ reported playing video games and thus represent the valid sample of the study. The mean age of participants was $Mn{=}27.6$ ($SD{=}5.8$), with 44 identifying as female (38.9%) and 69 identifying as male (61.1%). Converted to Likert scale ratings, the mean frequency of playing games was $Mn{=}2$ ($SD{=}0.94$), equating to playing games "Every week". Statistical tests use a significance level of 0.05 in this study.

Playing frequency was found to differ between genders (Mann-Whitney $U{=}1987$, $p{=}0.004$, two-tailed), with male participants playing more frequently than female participants.

Selection of Games On average, participants ranked $Mn{=}6.5$ ($SD{=}5.9$, $Mdn{=}3$) of the selection of 15 game titles, with $n{=}96$ ranking at least two titles and $n{=}2$ ranking all of them. The most frequently played game title was *Portal* ($n{=}66$), while the least played was *Metal Gear Solid V* ($n{=}19$).

As previously discussed, the selection of games was processed first through a weighted sum of rankings and later through the *TrueSkill* algorithm. An overview of the results is listed in table 4.3. The table illustrates that scoring based on the unweighted sum of ranks is closely tied to the playcount. Using a weighted sum as a curiosity score introduces several changes in the ranking, most notably by pushing *Zelda:BotW* to the first rank by a considerable margin. The ranking results of the *TrueSkill* algorithm shifts some of the middle ranks around, but is otherwise close to the weighted scores.

Given that the ranking results of the *TrueSkill* scores are methodologically more sound (see above), assessment of rankings is based on these.

Table 4.3: Comparison of ranking results based on playcount (how many participants have played the game), sum of unweighted ranks, sum of weighted ranks, and *TrueSkill* score ranking. All values are normalized to a `0` to `1` scale for better comparison. A value of `1.00` indicates the highest value of a given column, while `0.00` indicates the lowest.

Game Title	Playcount	Unweighted	Weighted	TrueSkill
Portal (1 & 2)	**1.00**	**1.00**	0.72	0.64
Elder Scrolls: Skyrim	0.94	0.97	0.79	0.71
Grand Theft Auto IV (or newer)	0.79	0.63	0.38	0.37
BioShock (any)	0.66	0.66	0.55	0.52
Mass Effect (any)	0.57	0.54	0.60	0.62
Super Mario Galaxy / Odyssey	0.53	0.48	0.47	0.58
Call of Duty: MW (1 & 2)	0.43	0.22	0.11	0.14
Uncharted (any)	0.32	0.32	0.40	0.37
LittleBigPlanet (1 & 2)	0.30	0.23	0.29	0.42
Batman: Arkham Asylum / City	0.28	0.31	0.50	0.51
The Last of Us	0.28	0.35	0.59	0.53
Red Dead Redemption	0.19	0.24	0.47	0.51
Zelda: Breath of the Wild	0.15	0.35	**1.00**	**1.00**
Street Fighter IV	0.06	0.00	0.00	0.00
Metal Gear Solid V	0.00	0.09	0.47	0.54

Suggestions by Game Curiosity Categories For the game suggestions per category module, a total of ***301*** unique game titles were mentioned, out of which ***136*** were suggested by at least 2 participants. The top 10 suggestions were: *Elder Scrolls* (suggested by ***39***), *Portal* (***36***), *Zelda:BotW* (***33***), *WoW* (***28***), *Fallout* (***22***), *Minecraft* (***18***), *GTA* (***18***), *Horizon: Zero Dawn* (***17***), *Final Fantasy* (***17***), and *The Sims* (***16***). A breakdown of suggested game titles per game category is shown in table 4.4.

Table 4.4: Game titles mentioned for each of the five curiosity categories (showing titles with at least 5 mentions). Titles in bold appear in multiple categories.

Game Category	Game Titles (Number of Mentions)
GEXP (“Explore”, “find out”) 92 unique titles	**Elder Scrolls (17)**, Fallout (14), Minecraft (11), Zelda: BotW (9), Dark Souls (8), **Horizon: Zero Dawn (8)**, The Witcher (8), Subnautica (7), **World of Warcraft (7)**, **Final Fantasy (5)**, Assassin’s Creed (5), Zelda (5)
GSOL (“Solve things”) 113 unique titles	Portal (29), The Witness (8), **Elder Scrolls (7)**, Myst (5), The Talos Principle (5)
GSAF (“Safe”, “stress-free”) 100 unique titles	**Sims (8)**, Stardew Valley (7), **Elder Scrolls (6)**, Cities: Skylines (5)
GCON (“Connect to people”) 84 unique titles	**World of Warcraft (13)**, **Final Fantasy (7)**, Journey (5), **Sims (5)**
GALI (“feeling alive”) 108 unique titles	GTA (7), PlayerUnknown’s Battlegrounds (6), **World of Warcraft (5)**, **Horizon: Zero Dawn (5)**, **Elder Scrolls (5)**

Ranking of the attributed game genres by *TrueSkill* scores results in the following normalized ranking (curiosity rank, count rank): *Social Sim* (***1.00***, ***0.08***), *Collecting* (***0.87***, ***0.10***), *RPG* (***0.80***, ***0.42***), *Exploration* (***0.76***, ***0.75***), *Story* (***0.58***, ***0.33***), *Task Sim* (***0.54***, ***0.17***), *Chance* (***0.42***, ***0.00***), *Strategy* (***0.36***, ***0.49***), *Reflex* (***0.29***, ***1.00***), *Puzzle* (***0.18***, ***0.52***), and *Frantic* (***0.00***, ***0.02***). Counts of suggestions per game genre ranged from ***10*** for *Chance* (normalized to ***0.00***) to ***318*** for *Reflex* (normalized to ***1.00***).

TrueSkill scores of game categories result in the following normalized ranking (curiosity rank, count rank): GEXP (***1.00***, ***1.00***), GALI (***0.32***, ***0.17***), GCON (***0.16***, ***0.01***), GSOL (***0.02***, ***0.74***), and GSAF (***0.00***, ***0.00***). Counts ranged from ***103*** for GSAF (normalized to ***0.00***) to ***180*** for GEXP (normalized to ***1.00***). Of note is that both GCON and GEXP had fewer unique suggestions than GSAF, even if GSAF had the lowest total suggestions.

Ranking of game genres was found to differ by gender for the genres *Strategy* (Mann-Whitney ***U=1911***, ***p=0.002***, two-tailed, lower ranking in females) and *Task Sim* (***U=1714***, *p=0.036*, two-tailed, lower ranking in females). Age was found to correlate with a higher ranking of the *Puzzle* genre (Spearman's *rho=0.226*, *p=0.019*) and a lower ranking of the game curiosity category GSAF (*rho=-0.231*, *p=0.018*).

Table 4.5: Two-tailed Spearman's rank correlations between 5DC dimensions and other measures. VS-MPR shows the maximum possible odds in favor of a hypothesis; i.e. of correlations between measures.

5DC Dimension	—		Measure	rho	p	VS-MPR
JE (Joyous Exploration)	—	Genre	RPG	0.2	0.037	3.019
	—	Game-based Curiosity Dimension	GCON ('connect with people')	0.234	0.016	5.617
DS (Deprivation Sensitivity)	—	Genre	Collecting	-0.193	0.045	2.655
ST (Stress Tolerance)	—	Individual Game	GTA (IV+)	0.252	0.007	10.607
	—	Individual Game	Zelda: BotW	-0.239	0.011	7.499
	—	Individual Game	Call of Duty	0.214	0.023	4.295
	—	Genre	RPG	0.293	0.002	29.545
	—	Genre	Puzzle	-0.226	0.018	5.037
	—	Game-based Curiosity Dimension	GSOL ('solve something')	-0.222	0.022	4.310
SC (Social Curiosity)	—	Genre	Social Sim	0.220	0.022	4.414
	—	Genre	Frantic	-0.212	0.03	3.535
TS (Thrill Seeking)	—	Individual Game	GTA (IV+)	0.279	0.003	22.456
	—	Genre	RPG	0.230	0.016	5.515

Individual Game *Genre* *Game-based Curiosity Dimension*

Assessment of the 5DC Questionnaire The aggregated results of the 5DC questionnaire were: *Joyous Exploration* (JE) *Mn=5.38*, *SD=0.86*; *Deprivation Sensitivity* (DS) *Mn=4.98*, *SD=1.15*; *Stress Tolerance* (ST) *Mn=4.36*, *SD=1.42*; *Social Curiosity* (SC) *Mn=5.11*, *SD=1.14*; and *Thrill Seeking* (TS) *Mn=4.20*, *SD=1.34* — each based on Likert scale ratings from *1* to *7*.

Demographic differences were found by gender, with ST being significantly higher in male participants (Mann-Whitney *U=978*, *p=0.001*, two-tailed), while SC was significantly higher in female participants ($U=1988$, $p=0.006$, two-tailed). Participants' age was found to be correlated with a lower score of SC (Spearman's $rho=-0.297$, $p=0.001$).

Significant correlations between 5DC dimensions and rankings are shown in table 4.5. For clarity, rho was inverted to match the meaning of an increase in the score of 5DC dimensions. This means that a rating of 1 in a ranking is higher than a 2, but 1 is lower than 2 in the 5DC questionnaire.

4.4 Discussion

This section interprets the survey results in the context of the study's three research questions. The most relevant results are visualized and repeated.

4.4.1 Game Titles and Genres That Elicit Curiosity

The primary goal of this study was to establish game titles and genres that have elicited curiosity as part of their gameplay. Through the responses of 113 participants playing video games, a list of popular games was ranked in terms of the curiosity they elicited. Additional game titles were collected and attributed to genres that were defined for this study.

Assessment of Game Titles The ranking of the 15 game titles selected for the survey is summarized in figure 4.1. Among these, *Zelda:BotW* stands out as being ranked highest in eliciting curiosity, by a margin of 40% above the 2nd rank, *Elder Scrolls: Skyrim*. This is despite the fact that the game has been played by only 23% of all participants, compared to 56% for *Elder Scrolls*. This means that when participants did play the game, it was likely to rank high in eliciting their curiosity.

Games in the list can be roughly positioned on a spectrum between games in which players have a great deal of freedom in choosing how to navigate the game world and games that restrict the movement options more narrowly. Describing the games from this perspective, *Zelda: BotW*, *Elder Scrolls*, *Metal Gear Solid V*, *Red Dead Redemption*, and *GTA IV+* give the player an enormous game world to freely explore. As part of the narrative, movement options might open up over time or are restricted for a predefined duration. However, overall, these games can be considered part of "open-world

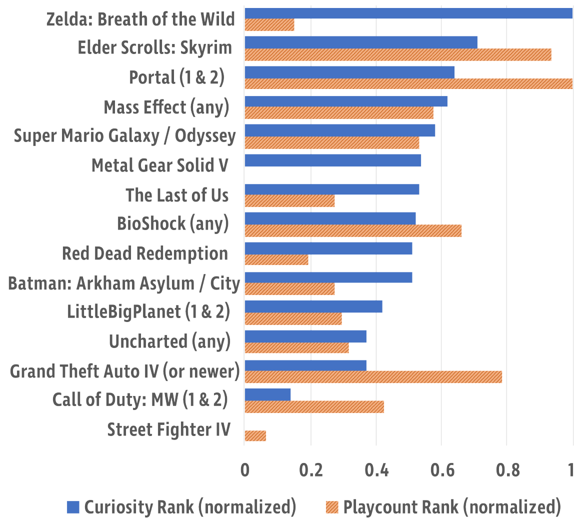


Figure 4.1: Shared selection of games ranked by how curious participants felt and how many participants had played them. Values are normalized to `0-1` for comparison (`0` for lowest rank and `1` for highest rank).

games", a genre label that is not strictly defined by specific gameplay but rather a combination of activities and environment properties. *Zelda: BotW* is unique among other open-world games in that players face almost no boundary that cannot be overcome. For example, players can climb on virtually all surfaces, and most of the activities in the game are optional and non-linear: players could choose to engage with the game's final challenge (combat against the series' adversary, "Ganon") almost from the beginning of the game.

In the middle of the spectrum are games with free-roaming sections (game levels) but requiring players to fulfill objectives within that section to progress to new areas. The exploration space within such levels can be reasonably large, but movement between levels tends to be limited or facilitated through a hub, such as a menu screen or overview environment (e.g., a game's world map). This is the case for the games *Portal*, *Mass Effect*, *Super Mario Galaxy / Odyssey*, *The Last of Us*, *BioShock*, *LittleBigPlanet*, *Uncharted*, and *Call of Duty*. *Batman: Arkham Asylum / City* can be considered an edge case, with *Arkham Asylum* being closer to segmented free-roaming and *Arkham City* being closer to an open-world environment.

On the other end of the spectrum is *Street Fighter IV*, a martial arts fighting game in which players face another opponent within a tightly spaced area.

Considering the ranking, it appears that curiosity in the context of gameplay was primarily assessed in terms of the ability to navigate the game environment; or, in other words, spatial exploration. It is essential to note that this interpretation of the results cannot be confirmed through the data collected in the study. It is a possible explanation for why some games have ranked higher than others, but it requires further investigation.

StreetFighter could have been interpreted as a source of curiosity for how other people react, i.e., social curiosity. However, this form of curiosity did not appear to have been at the forefront of participants' consideration when ranking the 15 game titles. Notably, *RPG* games such as *Elder Scrolls* and *Mass Effect* provide freedom not only in navigating space but also by impacting how a game's narrative plays out based on their interactions with other (non-player) characters. Here, the source of curiosity might well be based on spatial, conceptual, and social exploration. To recall, as mentioned in section **??**, each of these three describes different domains of exploration: either traversal of physical space (made virtual within video games) in spatial exploration, cognitive interpretation of information in conceptual exploration, and investigation of the intentions and behaviors of others in social exploration. To what extent each of these domains is represented in *RPGs* is difficult to determine, and perhaps it is, in fact, the involvement of all three domains that make the genre rank high in eliciting curiosity (as will be discussed in the next section).

Figure 4.2: Screenshots from the games *Zelda: Breath of the Wild*, *Elder Scrolls: Skyrim*, and *Portal*, the three highest ranked game titles.

Portal games are noteworthy in their ranking in the study, as the gameplay is confined to a relatively claustrophobic series of rooms in which players need to solve spatial puzzles. Curiosity in *Portal* is likely elicited by a combination of spatial and conceptual exploration. Despite the relatively small game environments, the game allows players to connect spaces with the "portal gun", a device that creates wormhole-like connections between two locations in the game. Through this device, the nature of spatial exploration is very different compared to other games. It is tightly integrated into a series of cognitive challenges that must be overcome to progress in the game. The game also stands out in its narrative, which surprises the player with changes about the nature of the game, ultimately provoking them to break out of the confines of the series of puzzle rooms. In the process, players can see behind the game spaces that appear to make up the boundary of the game. This is perhaps best compared to a movie that, halfway through its runtime, pulls back from the apparent narrative and reveals behind-the-scene stages of earlier scenes as part of the actual narrative.

The relatively low ranking of *GTA IV+* suggests that the ability to explore large game environments is not directly correlated to how curious players feel when playing. Games in the *GTA* series involve vast open worlds and various activities that players can pursue (e.g., car racing, bank heists, riding a roller coaster, and even participating in a virtual yoga session). A possible explanation for a lower ranking could be that both *GTA IV* and *GTA V* have tightly scripted narratives, with freedom given primarily between tasks that players are supposed to follow to progress. The majority of these tasks and other activities in the game are further focused on gun combat and car racing. This explanation of why it did not elicit much curiosity might be confirmed by the observation that *Red Dead Redemption*, made by the same developer, ranked higher. This game is structured very similarly to *GTA* games but provides a novel take on the *GTA* game structure. In *Red Dead Redemption*, players find themselves in a wild west environment, traversing the world on horseback rather than in a car. The game emphasizes a romanticized gunslinger atmosphere and uses a morality system in which the player's actions influence how other characters interact with the main character, possibly translating into a higher degree of perceived freedom. However, whether or not these explanations account for how these games elicit curiosity can not be based on the data gathered within the survey.

Participants submitted a large number of game titles as having elicited their curiosity across the five curiosity categories. However, less than half have been played by at least two participants, and only a handful of game titles having been submitted by more than 10 participants. Of the top 10 suggestions, four titles were already part of the selection of 15 game titles. Those not on the list included: *WoW*, *Fallout*, *Minecraft*, *Horizon: Zero Dawn*, *Final Fantasy*, and *The Sims*.

Of these, *WoW*, *Minecraft*, and *The Sims* are game titles that stand out as instances of eliciting curiosity in unique ways. *WoW* provides players with a vast world, but crucially, does so in a social setting. Players compete and collaborate in a shared virtual world, thus offering opportunities for spatial exploration and space for developing social curiosity. This is also true for *Minecraft*, with the addition that the game environment of *Minecraft* is practically infinite in explorable space. The algorithms that procedurally create the game environment are based on real-world principles and, as a result, are capable of shaping interesting landscapes. These can be mined for resources and used as the foundation for player-driven landscaping.

Finally, *The Sims* represents a game that does not feature much spatial exploration. Instead, it provides players with a canvas for building houses and playing out social scenarios through virtual avatars. In the case of *The Sims*, curiosity is most likely elicited by social curiosity; as interest in the relationships and circumstances of the virtual characters.

Assessment of Game Genres and Curiosity Categories Within the initial selection of games, the three highest ranked titles include the genres *Exploration* & *Puzzle* (*Zelda:BotW*), *Exploration* & *RPG* (*Elder Scrolls: Skyrim*), and *Puzzle* & *Reflex* (*Portal*). For these games, the genre labels *Exploration*, *Puzzle*, and *RPG* are most indicative of involving curiosity, with *Reflex* being more related to how success is achieved in the game.

The resulting *TrueSkill* ranking of genres among suggested game titles is shown in figure 4.3. While *Exploration* and *RPG* are ranked relatively high, the *Puzzle* genre is ranked second to last. This suggests that participants did not associate puzzle games with eliciting curiosity. *Portal* is not a typical puzzle game, as the game involves surprising moments in its narrative and gameplay. In contrast to other puzzle games, *Portal* sets expectations about the nature of the challenges that players will face, only to subvert them later in the game.

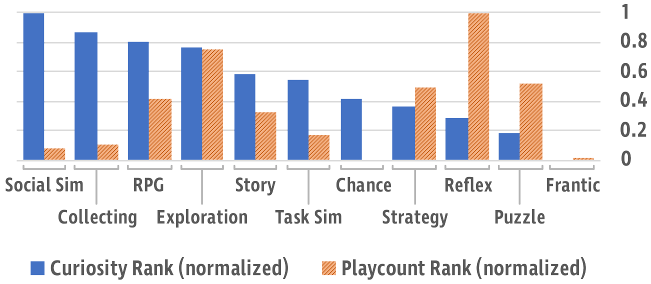


Figure 4.3: Game genres ranked by how curious participants felt in games tagged with the genre (blue), and how many games were mentioned for the genre (orange-striped). Values are normalized between `0` and `1`.

A surprising outcome of the survey are the genres that ranked first and second: *Social Sim* and *Collecting*. A relatively low number of game titles carried one of these genres, with only *Chance* and *Frantic* being used less often. Due to the high amount of game titles suggested, and most of those not having been suggested by many participants, it was not practical to create a ranking among all suggested titles. However, a few examples from these genres can be instructive in how curiosity is elicited.

In *The Sims* (*Social Sim* & *Task Sim*) and *Animal Crossing* (*Social Sim* & *Collecting*), most activities are centered around the day-to-day routine of virtual characters.

Within *The Sims*, players shape the homes and relationships of several characters. Even if they have considerable control over their characters' actions, the game involves frequent opportunities for emergent behaviors and interactions between characters. Following these characters' lives can elicit curiosity, similar to watching TV soap operas. Although the game does not explicitly create a narrative for players, Simlish, the fictional language used by characters in the game, conveys a sense of different emotions. Characters further indicate the topics of their interactions through iconographic thought bubbles and inform the player of their valence due to the interaction (ranging from very negative to very positive). As a result, players can get a vague idea about a dialogue between characters but are required to fill in more specific details mentally.

In *Animal Crossing*, players only control their player character. Other characters in the game go on about their own lives and have distinct personalities and hobbies they pursue. Activities in the game focus on acquiring various items, such as fishing or farming, that can be sold or used to improve the player's home or help other characters. Curiosity is likely elicited by getting to know the many different neighbors with which players share their village. Those may change over time, drawing from a roster of 413 distinct characters in the latest installment of the game series. *Animal Crossing* is also an example of the *Collecting* genre, which elicits curiosity by introducing uncertainty in activities connected to acquiring items. At first, many activities in the game yield seemingly random results. The act of fishing, for example, can yield 80 different fish species and various items (such as lost keys that can be returned to villagers). Over time, players can discover patterns that make specific catches more likely, such as discerning the shadow size of certain fish, preferred locations, and times at which they are most active. A similar depth of options is found in other activities, such as catching bugs or digging for fossils. In these cases, it is likely the uncertainty of what specific item will be acquired that elicits curiosity in players.

Another surprise of the resulting ranks is that the *Puzzle* genre ranked low, even though it appears to be a fitting genre to engage the *Deprivation Sensitivity* dimension of curiosity. To recall, the 5DC describes this dimension as the need for resolution, a need that puzzles seek to elicit as part of their design. Games suggested under the corresponding category (GSOL) are mentioned frequently but ranked low in curiosity (figure 4.4). It could be that this dimension of curiosity does not strike players as an essential component of curiosity. Interestingly, both *Zelda:BotW* and *Portal* rank high in the shared game list, despite carrying the *Puzzle* genre. For these games, it may not be that they include puzzles that elicit curiosity in players. Instead, exploration might be the most defining genre in *Zelda:BotW*, whereas *Portal* stands out with its unusual game mechanic and surprising narrative components.

Looking further at the ranking of curiosity categories, the GEXP category ranked far above other categories (figure 4.4). This suggests, again, that participants consider "finding out new things" dominant aspects of what elicits their curiosity in a game, compared to "solving" (GSOL) or "connecting to people" (GCON).

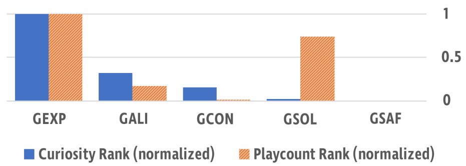


Figure 4.4: Curiosity categories based on the 5DC model, ranked by how curious participants felt in games provided under the category (blue), and how many games were mentioned for the category (orange-striped). Values are normalized between *0* and *1*.

4.4.2 Impacts of Trait Curiosity and Demographics

Considering the impact of trait curiosity dimensions (as measured by the 5DC) on other measures, a few significant correlations related to the research questions were found (table 4.5). To recall, the 5DC questionnaire is part of the study to answer RQ2 ("Do individual differences in trait curiosity dimensions impact what games and genres make a player curious?") and RQ3 ("Does age or gender impact what games or genres elicit curiosity?") through statistical assessments.

In terms of impact on the ranking of individual games, *GTA* was ranked higher by participants with increased *Stress Tolerance* (ST) and *Thrill Seeking* (TS), while *Call of Duty* (*CoD*) was ranked higher with increased ST. Given that both *GTA* and *CoD* were ranked low overall, this suggests that players do not consider these dimensions as defining what elicits their curiosity in a game. High ST and TS might impact what kind of games these participants play but not necessarily impact what stands out as stimulating curiosity. *Zelda:BotW* was ranked higher with decreasing ST. Here also, given the high rating of *Zelda:BotW*, ST does not seem to predict overall curiosity. It can be speculated that, despite having combat and potentially stressful elements, *Zelda:BotW* allows players that are easily stressed to express their curiosity still. On the other hand, to express curiosity in *GTA* or *CoD*, players require a higher stress tolerance.

Regarding genres, *RPG* was found to correlate positively with *Joyous Exploration* (JE), ST, and TS. What stands out, in this case, is that such a correlation is perhaps even more expected for the *Exploration* genre, which did not show any significant correlation. Role-playing also seems to involve social aspects, yet *RPG* was not found to correlate with *Social Curiosity* (SC). The best effort of interpreting this result is that *RPG* games elicit curiosity through spatial exploration and moments of high intensity, but are not solely defined by those, as would be the case for *Exploration* or *Reflex*. It might be that *RPG* represents somewhat of a balance between these genres and elicits curiosity more effectively as a result. This interpretation is supported by *RPG* having ranked higher than either of the two (figure 4.3).

Collecting was found to be inversely correlated with *Deprivation Sensitivity* (DS). This might suggest that a high need for resolution is more likely met with frustration than curiosity when faced with a game defined by extensive foraging. High ranking of *Puzzle* games inversely correlated with ST, suggesting that easily stressed players are more drawn to games that elicit their curiosity through cognitive challenges. For SC, *Social Sim* was correlated positively, and *Frantic* was inversely correlated. The impact of SC on ranking *Social Sim* makes intuitive sense and is most interesting in the absence of other such correlations (e.g., no correlation between JE and *Exploration*). Having little curiosity for *Frantic* gameplay might point at such games rarely focusing on game characters.

Notably, only two game curiosity categories were found to correlate with 5DC dimensions; and those did not correlate with what would be considered their respective dimensions. Games that emphasize the connection with people (GCON) correlated with JE, suggesting that games provided under that category might have involved exploration together with other characters or players. Games that let players "solve something" (GSOL) are inversely correlated with ST, similar to the *Puzzle* genre, and likely follows the same explanation.

In demographics, the study found only a few indications for impacts based on gender, age, or play frequency. Gender differences were found for the genres *Strategy* and *Task Sim*, which were ranked higher in eliciting curiosity by male participants. Age correlated with ranking *Puzzle* higher, although it should be noted that most participants were between 20 and 40 years old. It also inversely correlated with the ranking of games that elicit a feeling of safety (GSAF), suggesting that younger participants might still experience a higher degree of novelty when playing "stress-free" games such as *The Sims*.

4.4.3 Limitations

A few study design limitations should be noted when basing further work on the results and subsequent interpretations.

A fundamental limitation of the study is that the affective concept of curiosity and the definition of what constitutes a video game is not explained to participants. Both are frequently used terms in everyday language use but do not follow agreed-upon definitions. Therefore, the study's results reflect a wide range of interpretations that were not further captured in detail. The study did not ask participants to explain how they understood either of these terms; thus, it is impossible to assess how different interpretations affect the results. This limitation was deliberately accepted as part of the study design to assess curiosity through the lens of the emerging interpretations of video game players. However, it means that findings regarding the experience of curiosity are not instructive for a better understanding of curiosity as an affective construct.

The survey and all promotional material related to it were presented in English. This, in addition to the choice of online recruitment channels and the utilization of personal and professional networks in the Netherlands, makes it likely that most participants were English-speaking Dutch residents. Demographic data did not include information on the participants' residence and, therefore, cannot provide information about whether this impacted the results. It is reasonable to assume that the same survey conducted in other parts of the world would have generated different results, as familiarity with individual games and genres will differ.

Another essential aspect to emphasize is the use of the *TrueSkill* algorithm and the decision to have participants provide a ranking of games rather than evaluate them on a Likert scale. While the rationale for its use has been discussed in prior sections of this study, it remains an untested measure for evaluating player curiosity. Cross-evaluating the results of this study with other measures would help to strengthen the findings and solidify the viability of the *TrueSkill* method for ranking affective appraisals by participants, such as their curiosity.

It is likely that detail was lost by the decision to combine individual game titles of a series into single entries. This decision was taken to examine game design patterns rather than focus on specific, individual differences between titles. However, it is possible that doing so removes essential information, as the nature of what elicits curiosity within individual game titles might be very different.

For future studies, the game genre labels devised as part of the study require further examination. Depending on the game, using only two genre labels is not enough to describe what activities could elicit curiosity in players. Further investigations should explore the individual design aspects of the suggested titles and how they stimulate curiosity.

Finally, the interpretation of this study should not be that an *Exploration* game automatically elicits curiosity in players. A game might involve many aspects of what constitutes an *Exploration* game without successfully eliciting much curiosity. A gap remains between the intention of a game and its ability to realize that intention.

4.5 Conclusion

This study aimed to provide a starting point for considering what game titles and genres should be analyzed regarding their potential to elicit curiosity. Through the suggestions of survey participants, a list of 15 selected game titles was ranked by this criterium and assessed through the *TrueSkill* score algorithm. Suggestions of participants extended on that list and allowed for the ranking of game genres defined for the study. As a result, the study was able to address RQ1 by creating a corpus for further investigation.

The study found that the games *Zelda: Breath of the Wild*, *Elder Scrolls: Skyrim*, and *Portal* were ranked as the most successful in eliciting curiosity. Within these, the genre labels *Exploration*, *RPG*, and *Puzzle* are most representative of what activities in the game elicit curiosity. Among games suggested by participants, the genres *Social Sim*, *Collecting*, *RPG*, and *Exploration* ranked the highest; thus, providing evidence that the potential of *Puzzle* games to elicit curiosity is highly dependent on the game.

The study's results suggest that what makes players curious in a game does not systemically correlate to their scores on the 5DC questionnaire and, thus, their trait dimensions. Although some individual correlations with curiosity dimensions were found and described as part of the discussion, the results do not provide a sufficient basis for answering RQ2.

Results of the study further show that male participants ranked *Strategy* and *Task Sim* games higher in curiosity than female participants. Age was found to correlate with the ranking of *Puzzle* games, with older players ranking these games higher. The study answers RQ3 by revealing differences in what genres elicit curiosity based on age and gender. However, no significant differences were found in the ranking of individual game titles.

Overall, the results of the study provide evidence for the theory that games that strike a balance between uncertainty and structure tend to rank high. In contrast, highly deterministic games (requiring only cognitive or physical aptitude) or based on chance tend to rank lower in curiosity. How to strike that balance and whether that theory holds true will need to be assessed as part of future investigations.

The next step, based on the study's outcome, is to look at the individual games and genres that were most successful in eliciting curiosity. More specifically, it means investigating what design interventions are most likely to contribute to curious behavior in a game.

5 Design Patterns for Exploration

This chapter describes the formulation of development strategies, referred to as “design patterns”, that elicit curiosity and lead to exploration. The formulation of these patterns is motivated by the desire to operationalize the findings on what games elicit curiosity (see Chapter 4) and use them as a guide for hypothesizing testable design patterns that can be validated empirically.

> The research question that guides the work in this chapter is:
> **What design patterns can be hypothesized for games that elicit exploration?**

As will be discussed as part of this chapter, addressing this question necessitates choosing a focus for the kind of exploratory behavior that is investigated. Based on the survey results in Chapter 4 and the practicalities of validating player behavior in future steps, the aim is to define design patterns for *spatial exploration*.

In contrast to conceptual exploration, spatial exploration is the expression of curiosity in wondering about features and landmarks in an environment. In the case of video games, this exploration takes place in a virtual environment that otherwise mimics how a space can be understood: by traversing it and creating a mental model of the surrounding topography. This traversal, which can include the simple behavioral expression of “looking around”, operationalizes curiosity by measuring the space covered by a player within a virtual game world.

The chapter first examines how the use of design patterns has guided creative endeavors in the real world and aided the analysis and development of video games. It then discusses examples of game titles and genres from the previous chapter’s study to narrow down aspects that can inform testable design patterns.

These are the basis for formulating five design patterns, hypothesized to elicit the desire to …

1. Reach “extreme” points in the environment
2. Resolve visual obstructions
3. Investigate elements that appear out of place
4. Understanding how spaces connect
5. Forage for something in the environment

The chapter ends with concluding remarks on the hypothesized design patterns for spatial exploration and outlines the next steps for validating them in an empirical study.

5.1 Design Patterns: A Conceptual Tool for Analysis and Development

Before going into detail on strategies in video games that may motivate spatial exploration, it is crucial to understand the value and limitations of defining design patterns. *In this work, a “design pattern” is defined as the purposeful and repeatable implementation of creative decisions that lead to a pre-determined outcome.* Within this definition, there is an inherent tension between how successful a design pattern is in delivering an outcome and its repeatability in related but functionally distinct contexts. The more specific a pattern is to an individual use case, the less likely it is to be repeatable across different use cases. On the other hand, the more repeatable a pattern is, the more it runs the risk of being overly broad and not leading to the most optimal outcome. Alternatively, it may lack sufficient descriptive detail to support the analysis or development of creative decisions.

Nevertheless, supporting the analysis or development of such decisions is precisely the purpose and value of formulating design patterns. Any creative endeavor, be it the development of virtual environments or the writing of prose and code, includes a multitude of decisions that are taken throughout. Mapping out every decision of such endeavors would neither be practical nor be directly instructive for future work. Design patterns aim to formalize heuristics to learn from previous work and provide generalizable instructions.

A limitation of design patterns is that they do not provide detailed procedures. Design patterns need to be interpreted and re-contextualized when informing creative decisions for their specific use case. This makes it difficult to assess design patterns in terms of efficacy, as there is generally a large design space of possible implementations. As with all patterns, the interplay of seemingly connected aspects may be coincidental or less connected than hypothesized. A pattern may describe a set of circumstances and decisions but not have the outcome it is thought to have, even if well implemented. This is further complicated by the potential interaction between multiple design patterns within a designed artifact or space.

These limitations should not detract from the value that design patterns provide, as has been shown through their use in different fields and disciplines. Instead, they are a conceptual tool for dealing with "wicked problems" (Lönngren and Van Poeck 2021), challenges that are difficult to solve due to incomplete or changing requirements or solutions.

5.1.1 Origins of Design Patterns

Although the individual circumstances of design work can be highly idiosyncratic, they tend to involve similar problems encountered repeatedly in slightly different contexts. This understanding has been taken in formulating "patterns" in the seminal architecture book *A Pattern Language* (Alexander 1977).

In the book, the authors describe 253 patterns of architecture, urban design, and matters of community living. Each pattern addresses a strategy for dealing with a human need or problem related, in some form, to the design tools provided by the field of architecture. The patterns propose practical solutions at multiple scales, ranging from rooms and buildings to neighborhoods and cities. The formulation of patterns is not based on optimal solutions but on "best practice" hypotheses formed by heuristics in architecture.

One example, pattern number 62, "High Places", states:

> "The instinct to climb up to some high place, from which you can look down and survey your world, seems to be a fundamental human instinct."

This pattern is discussed as a need that should be kept in mind in the context of another pattern, the “Four-Story Limit” (pattern 21), which argues that a thriving community does not build beyond four stories on a large scale. The “High Places” pattern suggests that society has a need for dominating landmarks. The pattern suggests:

> “Build occasional high places as landmarks throughout the city. They can be a natural part of the topography, or towers, or part of the roofs of the highest local building — but, in any case, they should include a physical climb.”

The pattern’s description features a sketch that provides a good sense of the level of detail the authors aim for in the book. Although patterns are described with explicit solutions, how a solution should be implemented is left to the interpretation and sensibilities of those who put them into practice. Detail varies between individual patterns. Where “High Places” is described over three pages, “Connected Play” (pattern 68), which argues for the importance of shared play spaces, covers six.

Figure 5.1: Sketch of the “High Places” pattern from *A pattern language*, as it appears in the book.

It should be evident from this example that the authors were less interested in the optimal solution of individual architectural problems but rather provide a lexicon of possible tools. The authors frame this as the creation of a “pattern language”.

This approach of documenting common design challenges and solutions has been pursued under the same monicker in other areas outside of architecture. One of the more well-known examples is the book *Design Patterns: Elements of Reusable Object-Oriented Software* (Gamma et al. 1995), which deals with design challenges in software development. One of the discussed patterns is, for example, the “Singleton” pattern:

> “Ensure a class only has one instance, and provide a global point of access to it.”

This is followed by a description of the structure, consequences, implementation, known uses, and related patterns. The "Singleton" pattern refers to the concept of defining a programming class so that only a single implementation of it can exist simultaneously. Its implementation is a deliberate design choice to deal with a specific problem. That problem is that, in software development, it can be necessary (or at least beneficial) to create a single point of reference and ensure that no additional copy (referred to as instance) can exist at the same time.

Similar to the example of "High Places", the "Singleton" pattern is not described as a strategy that must be used but as a tool that can serve a need in specific circumstances while keeping other requirements in mind.

Before describing the use of design patterns in video games, it should be noted that the strategies considered to be patterns are rarely invented by the authors who describe them. Design patterns are efforts to formalize common strategies used within a field for a longer time. They stem from the observations of practices that have resulted in predictable outcomes, either beneficial or not. Indeed, patterns can also be described as anti-patterns, as strategies that should be avoided when designing for a beneficial outcome.

5.1.2 Design Patterns in Video Games

The area of video games presents a field in which architecture and software development intersect. As such, the aforementioned examples have served as inspirations for defining patterns in game development (as well as analyzing games). One example from the book *Game Programming Patterns* (Nystrom 2014) shows that design patterns may change over time or require additional consideration specific to the domain in which it is formulated. On the aforementioned "Singleton" pattern from software design (formulated by the "Gang of Four"), the author of *Game Programming Patterns* writes:

> **Singleton** "This chapter is an anomaly. Every other chapter in this book shows you how to use a design pattern. This chapter shows you how not to use one. Despite noble intentions, the Singleton pattern described by the Gang of Four usu-

> ally does more harm than good. They stress that the pattern should be used sparingly, but that message was often lost in translation to the game industry."

Aside from drawing from related fields, there have been efforts to formulate patterns concerning the design of games: the rules that govern how a game operates and how it is created. One example has been formulated in a game developer blog (Kreimeier 2002) under the label "Paper-Rock-Scissors" [sic]:

> "Avoid a dominant strategy that makes player decisions a trivial choice."

This pattern (or rather anti-pattern) describes the problem of players losing interest in a game if the choices they can make are realized as being obvious and lacking meaningful cognitive effort. It is worth noting that the analogy of "Tic-Tac-Toe" (or "noughts and crosses", "Xs and Os") might have been a better fit, given that Rock-Paper-Scissors involves an element of randomness that players have to consider. This makes the choice somewhat less trivial than if moves in the game were taken in order. Nevertheless, the pattern describes a relatively specific problem to game design.

Similar to the formulation of architectural patterns, game design patterns vary in specificity and require some interpretation for the individual use case. In the case above, the pattern requires the involvement of other design strategies for building the intended game experience without defining how a dominant strategy should be avoided.

Game design patterns can also be formulated in relatively neutral terms as strategies that may be beneficial or to establish terminology that has become used in the analysis and development of games. The book *Patterns in Game Design* (Bjork and Holopainen 2005) largely follows this approach, establishing terms such as "Boss Monsters" ("A more powerful enemy the players have to overcome to reach certain goals in the game.") or "Downtime" ("The player cannot directly affect the outcome of the game for a period of time.").

One of the examples in the book also shows that patterns have been formulated over time through the habits and customs of both developers and game players:

> **Easter Eggs**
> "Surprises in the game that are not related to the game. Easter Eggs are surprises put in games that do not necessarily advance the game story or even fit within the reality of the Game World. The design of Easter Eggs started as programmers' and game designers' ways of protesting against management but soon turned into a gameplay value, encouraging exploration and people to replay the games."

This example also shows that elements in the game that were initially not explicitly created to motivate exploration can become patterns that elicit curiosity in players. In this case, this happens through the known possibility that an *Easter Egg* might potentially exist and could be discovered by looking for it.

Game design patterns such as the *Easter Eggs* pattern hold the potential of being specifically valuable to elicit curiosity in games. While they lack specific instructions on how they should be implemented to lead to that outcome, they focus design attention on strategies that increase the likelihood of exploration.

5.2 Strategies for Eliciting Curiosity and Motivating Exploration

This section looks at strategies (i.e., design patterns) for exploration that can be formulated based on prior work and the results of Chapter 4. The starting point for this effort is based on the work of To et al. (2016), who reviewed the intersection of curiosity and uncertainty in game design.

The work of To et al. (2016) discusses existing game design strategies across multiple games and five factors of how exploratory behavior is exhibited, as formulated by child psychologists before (Kreitler, Zigler, and Kreitler 1975b). These factors should not be confused with the Five-Dimensional Curiosity Scale (5DC) of Kashdan et al. (2018), described in Chapter 4, which focuses on a person's general propensity for developing curiosity (i.e., their overall trait curiosity).

The work of these authors builds the foundation for the formulation of three types of curiosity-based exploration in this thesis: *conceptual exploration, social exploration,* *and spatial exploration.* These types will serve as design goals for discussing different design patterns in video game titles and genres.

The sources of these patterns are based on the highest ranked game titles in terms of eliciting curiosity in Chapter 4; *Zelda:BotW, Elder Scrolls: Skyrim*, and *Portal*. Each design goal further discusses the potential of game genres that are part of these games (*Exploration*, *Puzzle*, *RPG*, and *Reflex*), as well as the genres that were ranked highest by survey participants (*Social Sim* and *Collecting*). The *Exploration* genre is, by the definition given in section 4.1.7, a genre involving either conceptual or spatial exploration (or, indeed, both).

Following the discussion of conceptual, social, and spatial exploration patterns, the following section focuses on developing design patterns for spatial exploration through the topography of a game's environment (i.e., level design). For this reason, the subsection concerning strategies for spatial exploration is also going into more detail than the others.

This focus is chosen to enable an empirical investigation for hypothesizing design patterns. Spatial exploration is easily measured and less dependent on prior knowledge (as would be the case for conceptual exploration) or the involvement of multiple players (as would be the case for social exploration). As will be discussed later in the chapter, the formulation of spatial exploration design patterns is likely to overlap with other types of curiosity-based exploration (conceptual or social). It is intended to act as the primary motivation and is hypothesized to be the reason for expressed player behavior.

5.2.1 Strategies for Conceptual Exploration

Related survey genres: *Puzzle*, *Strategy*
Related survey titles: *The Witness* (Thekla, Inc. 2016), *Portal* (Valve 2007), *Elder Scrolls: Skyrim* (Bethesda Game Studios 2011)

Strategies for motivating conceptual exploration in games invoke the notion of being able to and tasked to solve a given problem. The *Puzzle* genre is perhaps the most literal implementation of this, presenting players with both a problem that must be overcome through cognitive effort, as well as rules and tools to do so. Conceptual exploration here means mentally navigating through the possible solution space, considering possible implementations of a solution given a set of rules and circumstances. Curiosity to engage in this form of exploration is elicited by the information gap of whether the given problem can be solved and whether a person is capable of solving the problem. Consistent with the information gap theory (Loewenstein 1994), curiosity will be felt stronger if the gap appears surmountable. In other words, if a puzzle appears not too challenging to solve.

Games that focus on conceptual exploration tend to be direct in pointing out to players that there is a problem to solve. The task is straightforward, and so is the implication that a solution is possible with the tools a game provides its players. Rules are similarly stated outright and tend to be what frames or complicates a given problem.

A typical design strategy of puzzle games is to introduce tools and rules connected to a problem incrementally. New rules can add complication to previous rules and thus intentionally limit the conceptual space of possible solutions to increase the difficulty. Curiosity for conceptual exploration can wane if the cognitive challenge reduces. This can happen even in a series of similarly challenging problems, as players likely learn to navigate the possible solution space more quickly, having learned from what worked in the past. With a decrease in difficulty comes a reduction in the information gap, as even if a player might not solve a problem immediately, they become more confident in their ability to do so. At this point, even a cognitive challenge can become a repetitive (but possibly still enjoyable) task rather than eliciting curiosity for conceptual exploration.

Figure 5.2: Screenshots of the game *The Witness* (left and middle) and *Portal* (right).

Video games such as *The Witness* and *Portal* are examples of games that stand out within the puzzle genre, as illustrated by their frequent suggestion from many participants for games that have elicited curiosity for solving things. Both games present players with a series of problems that are similar in nature. In the case of *Portal*, players can create wormhole-like connections between spaces to complete tasks, e.g., to reach a button opening the door to the next level. As players progress in the game, they are made aware of a meta-narrative that re-contextualizes what they have been doing so far in the game. The game narrative has players see behind the machinations of previous puzzle levels, giving them a sense of "breaking out of the game world", despite the "behind the scenes" environment of the game, of course, also being part of the game's design. In doing so, the game further elicits curiosity by suggesting to players that there is an information gap in the nature of what the game has presented itself to be. In the process, the game opens up an unforeseen, new possibility space that players had not considered, given that expectations had been set for a more narrowly defined possibility space before.

In *The Witness*, players solve a series of line puzzles presented within a larger virtual world that they can roam. For the most part, the game points players to where the individual puzzles can be found. Over time, however, the game provides hints that line puzzles can be found as part of the wider virtual world. This gives players a sense that more puzzles could be found within the environment's geometry, extending their understanding of what in the game can be considered a puzzle.

This strategy of starting with simple cognitive challenges that grow into raising questions about the very nature of the game has been part of several games; such as *Frog Fractions* (Twinbeard Studios 2012), a mathematics game that changes into several different types of games, or *Inscryption* (Daniel Mullins Games 2021), a card game that requires players to use ostensibly decorative elements in the environment to succeed.

Conceptual exploration in games can also originate from tasks that change depending on circumstances in the game. This is typically the case for strategy games where the overall goal is clear, but individual challenges within that goal are a matter of player choice. In strategy games, curiosity is elicited by the information gap of how player decisions will impact future game states, given a response of such decisions through the game's systems (often in the form of other players, whether automated or driven by human intelligence).

It should be noted that conceptual exploration can be a significant component in games that are not primarily about it. In the survey, participants considered *Elden*

Ring: Skyrim as a game that involves conceptual exploration, likely due to the choices that can be made within the game. As a role-playing game, the properties of the player character can be modified and impact how the game unfolds. Furthermore, choices made by the player can impact the game's narrative, thus leading players to wonder how their choices will impact other characters and events.

5.2.2 Strategies for Social Exploration

Related survey genres: *Social Sim*, *RPG*
Related survey titles: *The Sims* (Maxis 2000), *World of Warcraft* (Blizzard Entertainment 2004), *Journey* (Thatgamecompany 2012)

Social exploration in games can be understood as the interaction between human players, as well as interactions with virtual characters that act as projections of social motivations and behaviors. Games that are said to be character-driven, meaning that the narrative deals with the desires and motivations of its characters involve social exploration in the player's imagination. The information gap is in the uncertainty of how events impact the emotional state of characters in the narrative. It can also point players toward circumstances for which they do not know how they would respond to in their own lives. This allows players to experiment with social variables in a somewhat controlled manner, allowing them to learn more about how they would interact with others outside of the game environment.

The *Social Sim* genre invokes social exploration through the involvement of everyday tasks and actions. Not all such actions are necessarily connected to another character. It might involve mundane activities, such as getting out of bed or cooking food, as actions that players can take. By having players control the events of seemingly minute actions, they are more likely to identify and relate with a character. Like the characters in the game, players have thousands of small tasks throughout the day that often do not appear influential but make up most of the events in a day.

A straightforward implementation of this strategy is found in *The Sims*, a game series in which players control the everyday actions of multiple characters in a virtual world. The game does not have a predefined narrative. Instead, it gives players possible career paths (with in-between goals) and everyday tasks. Characters in *The Sims* make decisions themselves but can be instructed more directly by the player. This gives *The*

Figure 5.3: Screenshots from the games *The Sims* (left), *World of Warcraft* (middle), and *Journey* (right).

Sims a sense of playing with a virtual doll house in which the player creates the narrative. At the same time, characters in *The Sims* have their moods and reactions to events that are not fully controllable by the player, including how they will react to discussion topics. This keeps players invested in the game as their actions can only partially steer the virtual lives of *The Sims* while remaining curious about whether decisions that have been taken play out as players would expect them to.

Another form of social exploration can be found in multiplayer games, where the information gap is in the uncertainty of how other people react and respond to game situations. Multiplayer games exist throughout all game genres but can also fundamentally define the overall game experience in a way that could be seen as constituting a genre of its own. Some multiplayer games put players into competition with one another, thus putting the social exploration in a strategic realm of extrapolating how an opponent will respond to actions. While an opponent's play style can reveal their personality and emotions, social curiosity within competitive play is more likely to be restricted to exploring rational and strategic choices rather than emotional impacts.

Multiplayer games can also be collaborative by working together to accomplish a task or experiencing events alongside another player. For example, the game _Journey_has players wandering through virtual landscapes and coming across other players seemingly by chance. Here, a strategy to elicit curiosity for the "other" is restricting communication. In *Journey*, players can only use simple sounds and character movements to communicate, making any encounter with another player a game of signaling intentions. In this sense, *Journey* encourages reflection on the other player's intentions due to its design — something that would be lost if a more direct form of communication was made available.

Games that connect many players, so-called “massively multiplayer online” games, tend to involve both competition and collaboration. Social exploration in such games runs a wide range of motivations inherent in the design of such games to create large communities. Games such as *World of Warcraft* (*WoW*) involve tools that support communication among players as well as ways to establish organizational structures. Tasks in the game are intentionally designed to either functionally or practically impossible to complete without the combined efforts of multiple players. This requires effective communication in real-time to coordinate efforts. In contrast to *Journey*, *WoW* attempts to make communication between players as straightforward as possible and implements challenges that require a high level of communication. The game further provides players with many opportunities for social interaction that are not immediately in service of overcoming a given task (Chen and Duh 2007).

Another form of social exploration is motivated by games in the *RPG* genre. Roleplaying games have players assume a character that grows over time. This growth is usually rooted in the game’s narrative but also expressed through game systems, such as learning new actions that can be carried out in the game. This is exemplified in MMO games, such as *WoW*, where players’ interactions are mediated through player avatars. *RPG* games provide space for social exploration even in the absence of other players, as is the case in *Elder Scrolls: Skyrim*. Non-player characters in the game can respond differently depending on how players develop their player characters. *RPGs* often emphasize different outcomes based on the player character’s actions, including the possibility to act out dark or potentially uncomfortable personality traits in a safe environment. In such cases, the information gap that is addressed is, in part, in the self-exploration of players. As a result, roleplaying games are more likely to elicit curiosity if they provide players with unusual situations to act in.

5.2.3 Strategies for Spatial Exploration

Related game genres: *Exploration*, *RPG*
Related survey titles: *Zelda: BotW* (Nintendo EPD 2017), *Elder Scrolls: Skyrim* (Bethesda Game Studios 2011), *Minecraft* (Mojang 2011)

Games that elicit curiosity for spatial exploration provide players with a virtual environment that they can navigate in. This navigation is typically anchored in a player character, providing a third-person or first-person perspective relative to the player character. The information gap that motivates spatial exploration is not knowing what players might find at different locations in the game. Connected to this lack of information is the perception that something of value could be found in the environment. This could be either an object that is beneficial to the player through game mechanics (i.e., acquiring a resource in the game), gaining a better understanding of the environment's topography, or eliciting a sense of awe for discovering aesthetically pleasing locations.

Colloquially, the label "exploration games" is perhaps most directly connected to games in which players can roam freely within a large virtual environment and are encouraged to do so as part of the game's design. Players might be tasked to visit specific locations but are likely to find alternative paths or interesting elements. Alternatively, they might be called to forage for resources that are hidden within the environment. Such games might also be referred to as "open world" games, indicating that the game provides a significant degree of freedom in player movement. Although the scale of a virtual environment has a significant impact on the perceived exploration potential (i.e., how much space can be explored), this perception is impacted by how much of the environment a player can perceive at a given time, how fast they can move in the world, and how detailed the environment is. In addition, players are more likely to remain curious (or become curious repeatedly) if the environment continuously provides meaningful novelty. A very repetitive game world is easily confusing, as it becomes difficult for players to orient themselves. Meaningful novelty refers to the possibility that environments may involve factually unique locations that, although distinct, do not stand out as attractive to players.

Zelda:BotW is a noteworthy example of a game focused on motivating spatial exploration. Players are free to make their way through the environment early on in the game. The game provides the players with directions as to the overall goal of the game but does not restrict their movement should they go elsewhere. The game's design assumes and encourages players to venture throughout the environment before heading to their final destination, not only to gain experience and valuable game objects in the process but because the vast majority of the game's designed content is distributed throughout the game world. If players were to head to their goal as fast as possible, they would miss most of the game's narrative and gameplay experience.

Figure 5.4: Screenshots of Zelda:BotW (left and middle) and Minecraft (right).

Zelda:BotW furthermore encourages spatial exploration by giving players a rare ability within video games: the ability to climb on almost any surface. Typically, video games are keen to restrict player movement in areas that are not designed to be part of the gameplay experience. Detailed environments take a long time to create, and implementing interaction possibilities within such environments takes longer still. Even in large virtual worlds that are freely explorable, games typically restrict the kinds of actions players can take within them. Vertical locomotion (e.g., jumping, flying, or climbing) adds to the amount of space that players can reach, as well as see from higher vantage points, and thus adds to the amount of effort of creating such worlds. Climbing is rare even within these modes of locomotion, as it requires taking the surface of climbable environments into account. This requires further development considerations, such as determining what parts of a surface are climbable or using appropriate animations for different stages of climbing. Video games will frequently use predesignated objects as simulated climbing actions. In such a case, players cannot move freely but can decide which object to move to next. In *Zelda:BotW*, however, players can climb freely, primarily restricted by their stamina, a resource that can be extended through actions in the game. Overhangs and slippery surfaces remain off-limits to players and allow the designers to restrict some areas. However, for the most part, *Zelda:BotW* communicates to players that most of what they see in the game world is within their reach.

Although the vastness of the traversable space increases the boundaries of what can be explored, it can also be experienced as overwhelming for players. Even if games implement a high degree of interactive detail throughout a game world, there will always be areas with more or less for players to do. A large environment can thus feel disorienting if any direction for them to take seems to be as good as any other. Video games that motivate spatial exploration often introduce unique locations that provide information about their immediate surroundings. Such navigation nodes tend to stand out within the environment through tall structures or unusual objects. Visiting these nodes often provides players with a more detailed game map, allowing them to understand the surrounding environment with a bird's-eye view. It can also trigger the display of new game tasks and thus point players more directly to other things to do as a result of their exploration. By supplementing freedom of movement with smaller in-between goals that introduce new focus points, games such as *Zelda:BotW* or *Skyrim* aim to focus players' attention on where to explore next as a strategy for eliciting curiosity. Without this focus, players would still retain the freedom of movement but would be less aware of specific gaps in information.

A different approach to spatial exploration can be seen in *Minecraft*, a game that creates a practically infinite virtual environment for players that can be modified and reshaped at will. Although the game provides players with a goal, the means of getting to it is by mining for resources in the environment and using them to craft helpful tools. The way how players achieve that goal is left entirely up to them. As a result, the game environment does not promote a specific location within the created environment. Instead, it is a simplified representation of patterns found in nature. Mountain ranges, for example, are sloped and shaped realistically, if only at a much lower resolution. Flora and fauna in the game are roughly grouped into biomes, such as fields, forests, and deserts, that follow individual patterns for environment creation. The knowledge that the environment holds resources of interest anchors players to a specific task amidst all the freedom for exploration. Much of the spatial exploration in *Minecraft* can be considered foraging behavior. Players are not driven to specific destinations in the game but to any destination that might harbor a desired resource. Through ongoing foraging, players learn the game's patterns to distribute resources and thus become more targeted in their foraging efforts. Using such patterns allows the game to provide centers of attention for players relatively independent from their exact amount or location. This perception and successful recognition of spatial patterns can motivate spatial exploration.

Zelda:BotW also involves a foraging strategy, although to a smaller extent. The game hosts 900 so-called "korok seeds"; collectible objects that involve finding a small creature that holds it. These creatures tend to be hidden in the environment but feature distinct patterns that point to their presence. Some of these patterns also follow the convention of the aforementioned *Easter Egg* game design pattern by hiding creatures in seemingly hard-to-reach places or making them appear through seemingly unrelated unusual actions at specific locations.

With these examples in mind, the next section of the chapter delves deeper into how patterns in the game environment can motivate spatial exploration.

5.3 Formulating Testable Design Patterns for (Spatial) Exploration

This section presents the formulation of five design patterns for spatial exploration. More specifically, these design patterns are framed from the level design perspective, shaping the topography and architecture that make up the game environment. This still requires taking more general game design into account, as the abilities and challenges of a game directly impact its level design. It should be noted that the amount of formulated patterns is not meant to be exhaustive of all level design patterns that could be described. Instead, it is meant to exemplify the process, with some variations, of defining testable level design patterns based on prior work.

The patterns are formulated on the basis of work by Björk and Holopainen (2005), who cataloged a wide range of patterns in their book *Patterns in Game Design*. The descriptions include game titles discussed in the previous sections and similar game titles. Similarities come from how the environment is presented and strategies guiding players through a free-roaming world. The resulting patterns are thus also formulated for games with similar overall game design systems, i.e., that focus on an individual player character where most designed activities are distributed throughout the game environment in a non-linear manner.

Before discussing individual patterns, it is essential to note that design patterns are not necessarily strategies that compete against one another. Strategies can exist in parallel or interact with one another. Video games discussed in this section typically use several strategies to elicit curiosity for spatial exploration.

5.3.1 Pattern: Reaching Extreme Points

Video game environments may feature locations that are difficult to reach. Tall mountains might require long and arduous travel through challenging terrain. While reaching extreme points often involves covering a long distance, they can also be implemented on reasonably even ground if other obstacles make reaching a desired location more difficult.

Related game design patterns (Bjork and Holopainen 2005) include:

Outstanding Features — This pattern describes areas or elements in the game world that convey information to players by their appearance. *Reaching Extreme Points* are designed to stand out within the larger game environment, both in their aesthetic and in how challenging they are to reach for players. While not all *Outstanding Features* represent patterns of *Reaching Extreme Points*, the reverse is generally the case, as the degree of "extremeness" needs to be communicated to the player. Mountains, towers, and other tall structures are typical examples of outstanding features, especially when they are located far away from the boundaries of a game world. This keeps the pattern visible from most locations in the environment. *Zelda:BotW* features both tall mountains and observation towers that stand out in the game world. Even in a game with many mountains, unusual details can further emphasize specific instances. In *Zelda:BotW*, for example, one such instance is a prominently placed mountain that appears split in half, with a canyon leading through the center. The game *Horizon: Zero Dawn* (Guerilla Games 2017) features an example of a somewhat dynamic version of such an *Outstanding Feature*. In the game, so-called "Tallnecks" (large dinosaur-like robotic creatures with similarities to gigantic giraffes) roam at pre-defined locations in the game world. These creatures can be climbed and provide players with an overview of the environment.

Strategic Locations — This type of pattern refers to the advantage that players might have in reaching and staying at such locations. In the context of spatial exploration, 'control' can be understood as simply inhabiting a space with the player character. *Reaching Extreme Points* frequently involves reaching a location that is not only difficult to reach but also valuable once players have done so. Reaching a very high point in the environment allows players to see a large part of the surrounding environment, thus providing them with a lot of knowledge. They might also provide game items that improve the player character's abilities as a reward, thus providing a strategic advantage. Temples in *Ghost of Tsushima* (Sucker Punch Productions 2020) are both strategic in providing players with a high vantage point and new skills that players can subsequently use throughout the rest of the game. This aspect of *Reaching Extreme Points* can overlap with a pattern discussed later: *Foraging for Desired Objects*. Video games tend to combine patterns, and desired objects are frequently found at locations that are challenging to reach.

Overcome — This game design pattern involves defeating an opposing force. When *Reaching Extreme Points*, some form of opposing force must be overcome. With tall mountains, this force can be as simple as gravity, as any misstep by the player results in falling to the ground. Even when the game does not include a negative consequence in the form of simulated injury (i.e., damaging the player character), players lose time as they have to navigate back to where they fell. In the video game *Subnautica* (Unknown Worlds Entertainment 2018), the extreme point is to dive into the ocean depths that provide players with new resources. Instead of considering gravity, players need to be mindful of their oxygen level, which depletes over time and thus restricts how far they can get before returning to the surface. Just like in real life, this makes it dangerous to make mistakes in navigation when trying to leave an underwater chasm in time. Challenges can also come from making exact maneuvers to prevent the player character from getting injured. In *Zelda:BotW*, and many other games, spikes may surround a location, allowing players to overcome them through precise jumps or other forms of locomotion. Such "spikes" can be literal in indicating a clear danger to players, such as a moat of lava or acidic liquid, or metaphorical, via an increase in the challenge through game mechanics.

Based on these game design patterns, *Reaching Extreme Points* involve the combination of localized challenges that need to be overcome, providing strategic advantages for reaching the location, and having a distinctive appearance that signals to players that challenges will need to be overcome. In practice, this pattern is most prominently implemented through tall structures, indicating that the "High Places" pattern from *A Pattern Language* also applies in game worlds.

5.3.2 Pattern: Resolving Visual Obstructions

Within the game environment, individual game objects can obstruct the visibility of what lies beyond. Games may feature such obstructions deliberately and prominently to motivate players to discover what is being deliberately obstructed. Implementing this pattern requires signaling that something of interest could be found while maintaining ambiguity about whether that is the case or what could be found.

Related game design patterns include:

Fog of War — This pattern refers to the deliberate obfuscation of the game environment resolved by spatial exploration. *Fog of War* reduces visibility and represents a conceptual implementation of spatial knowledge of the environment. Typically, this pattern is more commonly found in games where players do not perceive the world through the viewpoint of a player character, e.g., real-time strategy games that are played from a bird's eye perspective. In such games, *Fog of War* is thus a representation of spatial information (or lack thereof) of characters with more limited information than players have given their vantage point. However, it can also be implemented as an area where visibility is temporarily obstructed, such as fog, heavy rain, or lack of light. In such cases, players must closely approach objects in the environment to see them clearly. The open-world game *Elden Ring* (FromSoftware 2022) can illustrate both forms of this pattern. The game map is initially blank and is only made visible as the player finds its pieces in a specific location in the virtual environment. While exploring the game world, players will also often enter areas (e.g., catacombs) with limited visibility, where the use of spells or items is required to proceed.

Imperfect Information — This pattern describes a deliberate withholding of information or an intentional decrease in the accuracy of the information provided to a player. In the context of the *Resolving Visual Obstructions* pattern, game elements (including a game's topography) are used to obscure parts of the game that could be of interest to the player. To provide *Imperfect Information*, players need to suspect that obstructions could result from deliberate implementation. In other words, the information that "something might be there" is communicated ambiguously. In *Elden Ring*, this is furthermore illustrated by the game map. In addition to starting out blank, the size of the finished map is not initially communicated to the player. This means that the potential map space expands as more pieces are collected, making the player realize that the game world is more extensive than they initially thought and wonder how large it will become.

Secret Resources — The *Secret Resources* pattern refers to the involvement of rare resources that are seemingly not meant to be discovered by the player. Such resources are ultimately still designed to be found but are sufficiently hidden to require closer investigation to be localized. The game *Ghost of Tsushima* has many different types of world elements or collectibles to be found, most of which are marked on the map. One exception is the placement of hidden altars, of which the game does not inform the player that they exist. They do not look like altars and are identifiable in the game environment only by a wooden sign that signals the player should perform a bow. This is done by making an appropriate gesture, which, when done correctly, results in a visual effect surrounding the player.

Easter Eggs — As mentioned earlier, the *Easter Egg* design pattern refers to surprising elements in the game that are not directly related to the overall gameplay. *Easter Eggs* can range widely in implementation, and players will look for them, partly because they may expect them from a particular developer. Developers may, for example, include references to their previous games, e.g., an arcade machine of *Crazy Taxi* (Hitmaker 1999) in *Two Point Campus* (Two Point Studios 2022) (both published by SEGA) or multiple references in *Grand Theft Auto V* (Rockstar North 2013) to the protagonists of the studio's previous games, pop culture, and real-life people and events.

With these game design patterns in mind, the pattern of *Resolving Visual Obstructions* involves discernible obstructions within the game environment that suggest that something might be found upon closer inspection. Such obstructions are generally easily resolvable through spatial exploration and do not involve additional challenges. Instead, the challenge is in recognizing that there are resources in the environment that are intentionally hidden and discerning which areas in a game might harbor such resources. Exploration motivated by this pattern may also result from looking for *Easter Eggs* in the environment that are often found at similar locations as *Secret Resources*.

5.3.3 Pattern: Out-of-Place Elements

Video games can motivate spatial exploration with game elements that appear out of place in the context of their surrounding environment. In contrast to elements explicitly indicated as locations of interest by the game, *Out-of-Place* elements elicit a sense of uncertainty. Their appearance is unusual enough to be noted by the player but often does not inform them what they might find upon closer inspection.

Locations of Korok seeds in *Zelda:BotW* are indicated by a variety of *Out-of-Place* elements in the game environment. Players rarely see Koroks directly. Instead, they can notice elements in the environment that hint at their presence close by. An example of such an element is the placement of three identical-looking trees, where one tree has an extra apple hanging from a branch. However, players manage to do it once they remove the extra apple, and thus make the three trees look identical, a Korok appears to reward players with a Korok seed.

Related game design patterns include:

Outstanding Features — This pattern, mentioned earlier, refers to areas or elements in the game world that convey information by their appearance. In contrast to its involvement in the *Reaching Extreme Points* pattern, *Outstanding Features* can stand out on a small scale. Areas in the game might be intentionally lit in a slightly different way. Players could also encounter game elements that are either entirely unfamiliar or encounter familiar elements in an unusual environment. Drawing on the example of the three trees in *Zelda:BotW*, a golden tree could have elicited curiosity as representing something entirely unfamiliar. However, a familiar tree can appear unusual when accompanied by two other identical (or close to identical) trees close by. The artifice of these trees in an otherwise more natural-looking environment makes them appear unusual.

Clues — This game design pattern refers to elements that provide information about how a goal can be reached. Games frequently feature *Clues* close to the game elements that need to be interacted with to progress. *Clues* are defined by communicating some information to players while also maintaining a degree of uncertainty to not act as an outright solution. In the example of the three trees in *Zelda:BotW*, the apple that is only on one of the trees acts as a clue by being in proximity of an *Outstanding Feature* and also being an object that players can interact with. *Clues* do not always require actions from the player. They might also provide information that can be useful at a different location in the game or lead toward a specific location. A dynamic implementation of this pattern can be found in the game *Ghost of Tsushima* where the player can encounter foxes and tropical birds that, if followed, lead players to locations of interest.

The combination of these design patterns, or, in other words, the use of outstanding features as clues for the player, communicates that there is something of interest for players to discover. Video games frequently involve this pattern to integrate small cognitive challenges that yield some reward when solved. *Out-of-Place* elements are used to lead players to such challenges and cause players to be mindful of other instances of the pattern in the environment to discover more of such activities. It might also lead players directly to resources, thus rewarding players for recognizing that an element stands out against the environment.

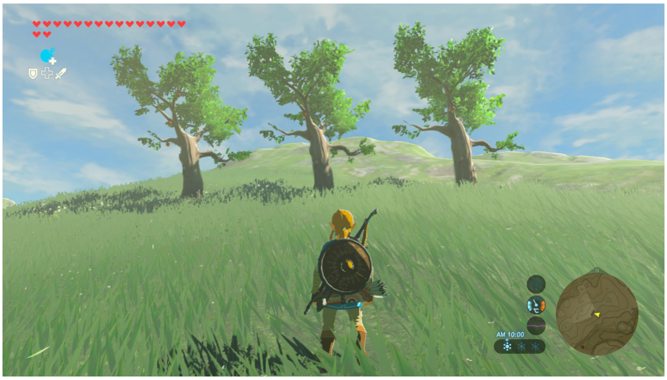


Figure 5.5: Screenshot of *Zelda:BotW*, showing three identical-looking trees but with one carrying more apples than the others. Players can pluck the extraneous apples to make the trees identical and thus receive a reward from the game.

5.3.4 Pattern: Understanding Spatial Connections

Games may involve complex paths to motivate spatial exploration, either through intricate interconnectivity or through obfuscating the endpoint of a path (e.g., in a labyrinth). They might also explicitly query a player's understanding of a specific location, for example, through a simplified treasure map that requires players to determine a location in the virtual environment.

Games that motivate spatial exploration frequently implement a single, coherent game world. That is in contrast to games that use several game environments and transport the player character between them. In practice, most games involve several environments, but games that present a single coherent world involve strategies for loading and unloading unseen areas without players noticing.

If players understand themselves to interact within a coherent game world, they become aware that most of what they see in the environment is potentially accessible. The challenge is finding out how to reach locations for which it is not apparent how they can be reached. This challenge is generally lower in *Zelda:BotW*, where players can climb on most surfaces and thus can reach most locations by taking the shortest route. A contrasting example is *Dark Souls* (FromSoftware 2011), in which players explore a large castle with many interconnected passages. Locked gates separate many areas in the castle that players can see through. This gives players an idea of how spaces connect, even when they do not yet know how to reach them. The limited visibility into a neighboring but unreachable space can still provide information as to how it may be reached or make players aware that there is a space that could be discovered.

Related game design patterns include:

Traverse — This game design pattern refers to the goal of relocation from one position to another. The challenge of reaching the new location is either in the distance that needs to be covered or in overcoming elements that keep players from reaching it. *Traversal* can also result from unstated, player-driven goals to investigate environmental elements. Games in large coherent worlds frequently require players to visit new locations far from where they are. In doing so, players extend their mental map of the environment, providing them with a more focused sense of uncertainty for locations that have remained unvisited between the places they did visit.

Obstacles — The *Obstacle* pattern involves game elements that hinder the player from taking the shortest route between two places. Such *Obstacles* can be in the shape of topographic features that impede movement at specific locations or moving entities that threaten the player. In practice, video games tend to feature both to provide a variety of challenges. *Obstacles* are generally visible to the player and are meant to cause a change in behavior by the player to overcome them.

Inaccessible Areas: This pattern deals with areas in the game that players can perceive but cannot enter. *Understanding Spatial Connections* does not require players to access all areas, as long as they can perceive enough of an area to add it to their mental map of the environment. However, *Inaccessible Areas* might also not be inaccessible forever, and players might be motivated to consider such areas as explorable in the future.

Eliciting a desire for spatial exploration through *Understanding Spatial Connections* involves mapping out an environment by traversing it and coming across seemingly inaccessible areas. Such areas might appear inaccessible due to topographic obstacles or other elements that hinder a player from reaching the area.

5.3.5 Pattern: Desired Objects Foraging

Games frequently feature objects that offer either beneficial effects or are otherwise desirable to obtain. In many cases, these objects are placed in such a way that their discovery is a challenge in itself. Players are made aware of the existence of objects or are even prompted to look out for them as the game progresses. The collection of such elements can be a motivation in itself that has more to do with amassing beneficial resources than the process of looking for them. However, players might also enjoy the activity of potentially finding something of value in the environment. Games may also task players to gather a certain amount of objects, thus reducing the importance of individual items.

When players know that the environment might hold specific objects of interest, they are likely to look for locations that indicate the presence of such objects. The word “object” might suggest a relatively small size, but it includes structures that can be entered by the player, as is the case with shrines that can be hard to find in *Zelda: BotW* while also being frequent enough to be seen as part of a collection.

Related game design patterns include:

Collection — This pattern refers to completing subgoals that form a coherent unit. Subgoals can be as simple as acquiring an object. Indeed, *Collections* are often presented by physical fractions of a larger whole, such as shards that can be assembled into a crystal or image fragments that form a bigger picture. While collected items might be beneficial to players, the focus is on the task of acquiring more of them. As a result, games often reward players not for collecting a piece of a collection but for completing it.

Pick-Ups — This pattern refers to the ability to acquire items in the game environment, typically close to the player character's location. Individually, such items are referred to as *Pick-Ups* and often impart a benefit to players for being picked up. In contrast to *Collection*, *Pick-Ups* focus on individual items and their relevance to the player. Such items will often come in the form of equipment (e.g., weapons or clothing) or consumable items (e.g., potions, food, arrows) that the player can use.

Desired Object Foraging motivates exploration by the awareness that something of value can be found in the environment without a specific indication of where such objects might be found. As a result, exploratory behavior is less directed but occurs with heightened awareness about details in the environment. Games involve object foraging as a strategy to put players in a state of being more aware of their surroundings and thus also more likely to notice other design patterns for more targeted exploration.

One challenge of considering object foraging a strategy for motivating spatial exploration is that ongoing foraging can be due to requiring a resource that can be found rather than the conceptual hunger that curiosity represents.

5.4 Conclusion

This chapter discussed design patterns in different fields and in the context of video games. A short list of five design patterns has been described in detail to formulate testable patterns for spatial exploration. For each of these, a description of related game design patterns (based on Bjork and Holopainen 2005) outlines how spatial exploration is motivated.

The five design patterns directly address the research question stated at the beginning of the chapter as to what design patterns can be hypothesized. As mentioned in the chapter, these five are not formulated to provide an exhaustive list of design strategies but as a step towards the empirical study that can assess the efficacy of hypothesized patterns. The theory presented in this chapter can form the basis for further formulation of design patterns for different types of exploration.

The next step to conducting an empirical evaluation of the design patterns formulated in this chapter is to develop specific instances of these patterns in a playable game. This process is described in the next chapter in the context of developing and piloting a case study game.

6 Level Design for Spatial Exploration

The following chapter describes the design and development of the research game *Shinobi Valley*. This game is created to test level design variations and empirically measure player behavior changes. The design of its virtual world is a direct implementation of the testable design patterns for spatial exploration proposed in Chapter 5.

> The research question guiding this chapter's work is:
> **How can design patterns for exploration be implemented and evaluated for empirical study?**

Readers are recommended to refer to the Open Science Framework (OSF) repository of this study for a video of the game environment:
https://doi.org/10.17605/OSF.IO/MVR37

The study design of the *Shinobi Valley* experiment can be divided into two parts: the pilot study (discussed in this chapter) and the experiment (discussed in Chapter 7). This chapter provides a detailed description of the game's design, including how specific instances of the design patterns for spatial exploration are developed as part of its environment. It then discusses the pilot study, which investigates whether the developed instances of the design patterns are, in fact, capable of eliciting exploratory behavior in players, as well as the perceived quality of the game and its suitability for larger-scale testing.

This chapter addresses the research question by describing the implementation and evaluation of a particular subset of design patterns focused on spatial exploration. As such, it can serve as an example for future studies aiming to implement and study other design patterns for exploration in various forms.

It should be noted that, to test individual patterns, the game and study design are tailored to examine those specific patterns. Such customization is necessary to evaluate the efficacy of individual design patterns. The combination of patterns selected for this study should show an impact on the exploratory behavior of players; otherwise, there would be insufficient evidence that level design patterns can motivate players to explore on their own accord. Any limitations in implementation and the effect on player behavior are examined and discussed in detail as part of the experiment described in Chapter 7.

The most important outcome of this chapter is the documentation of design decisions made in the creation of *Shinobi Valley*, and the successful evaluation of its efficacy to motivate exploration through a pilot study with 24 participants. Before this study, no study attempted to measure the impact of level design patterns. Furthermore, until now, no game has been available to game researchers that allows for such a study while also capturing the necessary data to assess player behavior.

While this work is in service of the overarching research question, this particular pilot and experiment focus on design patterns for spatial exploration. An additional concern of the pilot study is assessing the game's quality for its use in a larger experimental study. Thus, the pilot study aims to answer the following research questions (RQs):

1. Do the implemented level design patterns motivate players to go out of their way to explore them?
2. Is the quality of the game sufficient to not negatively impact player behavior?
3. Does the game provide sufficient opportunities to gather behavioral data?
4. Does the game operate reliably?

The following sections describe the design of the game, the integration of design patterns, and the results of the pilot study. It is important to note that not all functionality described in this chapter is used in the pilot study. At the time of the study, some functionality was not yet completed but was also not required to fulfill the purpose of the pilot. As a result of the pilot, functionality was also modified or removed. Differences between the experiment (described in Chapter 7) and the pilot study are indicated throughout the chapter where necessary.

The chapter concludes by discussing the results and considerations of the pilot study before continuing with the experiment in the next chapter.

Chapter Publications

Work presented in this chapter has been published in this peer-reviewed venue:

- **Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion (CHI Play Conference) – 2019**
  "Shinobi Valley: Studying Curiosity For Virtual Spatial Exploration Through A Video Game" (M. A. Gómez-Maureira et al. 2019)

6.1 About the Game: Shinobi Valley

Shinobi Valley figure 6.1 is designed as a single-player, third-person video game reminiscent of action-adventure games such as *Zelda: Breath of the Wild* — shortened to *Zelda:BotW* (Nintendo EPD 2017). Action-adventure games are loosely defined by requiring players to act quickly in real-time, usually by taking control of a virtual player character, such as "Link" in *Zelda:BotW*). They also involve narrative and situational challenges that players must overcome to progress in the game's narrative. Both aspects, *action* (requiring fast reflexes) and *adventure* (overcoming obstacles as part of a narrative), are implemented in *Shinobi Valley* on a rudimentary level to remain accessible to a wide range of people. This allows for experimental testing with a general audience, i.e., those comfortable with using a mouse and keyboard and capable of understanding the movements of a virtual character in 3D space.

As discussed earlier, many existing video games involve spatial exploration to varying degrees. In some games, such as *Zelda:BotW* or *Minecraft* (Mojang 2011), exploration can even be considered the game's primary purpose, featuring many design patterns that encourage it. Why, then, does it make sense to develop a video game for research purposes when existing entertainment games could be used instead?

What makes *Shinobi Valley* worthwhile for investigating design patterns is the amount of control it affords for research purposes. The majority of video games are developed to entertain their players. Rather than emphasizing specific design patterns or game

Figure 6.1: Screenshots of the game in the nature aesthetic. Player character walking on the primary path (left), and looking down from a mountain (right).

mechanics, they involve a wide range of them simultaneously to provide an interesting experience to players. This makes it difficult to assess to what extent each intervention contributes to the overall experience, especially since that experience is often more complex than *just* eliciting a desire for exploration. Setting up a controlled player experiment in an existing entertainment game would be highly ecologically valid but also packed with numerous confounding variables. Developing a purpose-built game makes it possible to aim for a deliberate balance between experimental control and ecological validity (Järvelä et al. 2015). While *Shinobi Valley*'s was created based on design heuristics, creating a new game can also cause unintentional consequences on the research results. The implications of this are reflected on in detail as part of the experiment, discussed in Chapter 7.

Apart from this balance, there are additional benefits to foregoing existing entertainment games for experimental purposes:

- **Free control over what can be logged.** Commercial video games rarely provide access to the underlying programming code, thus making it difficult to track and log game states. Open-source video games can mitigate this lack of access but are comparatively rare and often uneven in their aesthetic quality and usability design.
- **Ability to design for a manageable experiment length.** Existing video games are often meant to be played for several hours. Furthermore, games that focus on spatial exploration tend to be longer than games that ask players to face cognitive challenges or require fast reflexes. For experiment purposes, the overall duration

of an experiment needs to be kept as short as possible to ensure that participants experience a similar amount of content.

◦ **Ability to develop online and offline versions.** In developing a game for research purposes, versions can be created for testing in a lab setting (offline) and over the Internet. Offline testing allows for more detailed experiments that can include direct observation or physiological measures, while online testing can reach a larger amount of participants. Both may be combined to develop an experiment that supplements statistical data (gathering information from as many participants as possible) with more in-depth data points (more elaborate experiment setups with fewer participants).

Because of these reasons, *Shinobi Valley* is designed based on existing games rather than conducting experiments that use them directly.

Shinobi Valley is developed as a serious game to study players' behavior. The term "serious game" can bring to mind specific interpretations of how such a game might look and play because such games often pose clear educational or training goals. However, serious games are not defined by whether they educate but rather by what motivates their design and development: providing a non-entertainment purpose (Deterding et al. 2011; Harteveld 2011). In *Shinobi Valley* that purpose is to act as a testing environment for capturing and analyzing player behavior.

For players, this is evident in how the game is presented to them before they play it. *Shinobi Valley* is presented to players as "a gameplay experience research game", thus stating outright that playing the game fulfills a research purpose. Furthermore, most players will be made aware of the game through the context of finding participants and not on its own merits as something they might want to play, regardless of its connection to academic research. Although players are reminded of their role as research participants at certain moments (e.g., by asking for their feedback within the game or directly after it), the game is designed to get them into the mindset of playing an entertainment game. This mindset can be encouraged by typical game aesthetics and conventions outlined in this chapter.

This duality of *Shinobi Valley* as a video game and experiment tool makes it essential to distinguish between what perspective is described. In the current chapter, the focus is on the game's design and how it is presented to *players*. In Chapter 7, the emphasis is on the design of the experiment and how it is presented to *participants*. While there is overlap between the two perspectives, the distinction is important to note because the two roles exist in different contexts, even if they are assumed by the same person in this study. The game features design considerations for either of these roles. For the most part, the game is designed for video game players, given that it aims to simulate the experience of a commercial entertainment game. Whenever the game prompts players for research-related feedback or communicates information about the larger experiment, players switch their role to that of research participants.

When players start *Shinobi Valley*, they take the role of a monkey character in a ninja outfit ("shinobi" means ninja in Japanese). The ninja trope and the use of anthropomorphic characters are intended to create a playful backdrop to communicate to players that they are about to enter what is often referred to as the "magic circle" in the field of game studies (Huizinga 1971). They are entering a state of make-believe in which they suspend their disbelief in what could be considered realistic. This is easier to accomplish if the game world establishes a consistent look and feel, asking players to take on the role of a different entity rather than playing as themselves. Here the use of tropes, such as assuming the role of an agile ninja, can help players extend the explicitly shown and told narrative with their imagination, thus making the world appear richer in their minds.

Players see their character from a third-person perspective and find themselves in a 3-dimensional environment (figure 6.1), with a visually emphasized path leading them to their ninja master (figure 6.2). In order to test whether game design patterns motivate players to explore, the game is played in different experimental conditions. Depending on the condition, the game environment is shaped differently. For example, players in the *patterns present* condition can reach mountain peaks that are not present in the *patterns absent* condition. Two underground paths also only exist when patterns are present. The presence or absence of patterns is localized at "Pattern Instantiation Regions" (PIRs). The visual aesthetics differ depending on the experiment condition, with one featuring a *nature aesthetic* and the other presenting an *alien aesthetic* to players. A more detailed description of the experimental conditions and a rationale for their implementation are discussed in 7.

Figure 6.2: Bird's-eye view of the game environment with screenshots from various locations. The topography differs depending on whether spatial exploration design patterns are present. The map indicates the locations of Pattern Instantiation Regions (PIRs).

Regardless of the experimental condition, players can freely explore the environment surrounding the primary path. The explorable area is bounded by a perimeter of cliffs and other natural blockades. In the northwest quadrant of the terrain, a deep chasm prevents players from taking a shortcut but still allows them to see where the path they are following will lead them. While players are ostensibly tasked with following the primary path, given its very presence, the environment is designed to reveal as much as possible about where that path will take them. This is supposed to reduce the curiosity players might experience about the primary path itself, thus allowing for attention to wander toward the surrounding environment.

Within the environment, players of the *patterns present* condition can encounter several Pattern Instantiation Regions (PIRs). Each of these regions involves one of five design patterns hypothesized to invoke a desire for spatial exploration (see Chapter 5). All the patterns are visually distinct from the rest of the environment in some form. This is the case even for PIRs that feature *Visual Obstruction* (OBS) patterns, as that obstruction is still a visual feature. It is important to note that the game environment is not a featureless wasteland between these regions. Vegetation and terrain formations are designed to create an aesthetically pleasing and diverse surroundings for the player. The difference in the design is that their appearance does not suggest that players can find more upon closer investigation.

While players face no time pressure to finish the game in a certain amount of time, the game is designed to take around 10 minutes, assuming that players leave the primary path to explore the environment. Once players reach the end of the path, they encounter a ninja master in meditation. They are then told to wait five more minutes before they can interact with the master. This means the game is designed to make players wait for approximately half of their playtime. Capturing player behavior during a forced waiting period allows for assessing players that are primarily motivated by reaching the end of the path. For players that follow the path as quickly as possible, the play time can be as short as seven minutes, including the waiting time.

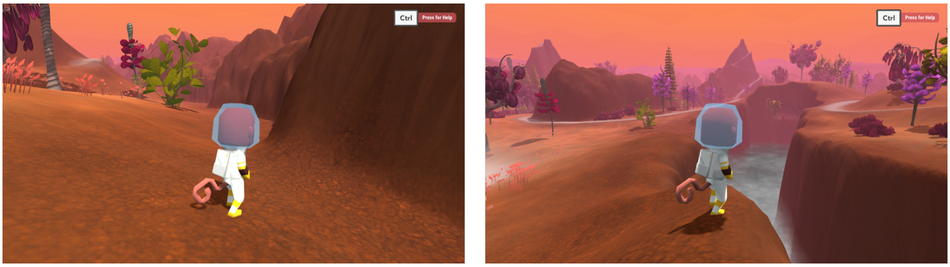


Figure 6.3: Screenshots of the game in the alien aesthetic. The Player character stands next to the cliff perimeter, restricting the explorable area (left) and standing next to the chasm in the northwest quadrant of the environment (right).

Shinobi Valley does not involve any hostile characters ("enemies" in the parlance of video games) or other threats. Players can jump from tall mountains without suffering any consequences. Players who jump into the chasm in the northwest quadrant are automatically transported to a nearby location next to it. This transport is accompanied by a visual fade-to-black and a gong sound effect. Both effects are reminiscent of similar mechanics in video games in which players are prevented from losing due to falling out of the explorable environment (referred to as "respawning"). In general, there is no actual losing condition in *Shinobi Valley*, as players can always complete the game by going to the master after they finish meditating.

The following sub-sections describe parts of the game design of *Shinobi Valley* in more detail.

Pilot Study Note:
The pilot study only uses the *pattern present* condition in the *nature aesthetic* to assess first whether patterns elicit curiosity. Additional conditions are only included in the wider study.

6.2 Game Controls

The control scheme in *Shinobi Valley* can be conceptually separated into *user interface controls*, such as activating the help menu or confirming information text, and *action controls*, which directly affect the player character. Players are at all times in either one of the two control schemes; never in both at the same time. For the most part, players take direct control of the player character, which is done by using a keyboard and a computer mouse or a mouse alone.

The *user interface control scheme* automatically becomes active whenever the game presents information in the form of text to the player. At that point, the player loses direct control of their character, and their mouse cursor appears on the screen. In this control scheme, players use the mouse to interact with buttons in the interface or left-click on message boxes to progress. Once all messages in a series have been shown, e.g., to explain how to control the player character, the control scheme switches to the "action control scheme".

In the *action control scheme*, players directly control the movements of their player character. The only user interface element visible when players take active control over their character is a visual reminder of what keyboard key they can press to open the help menu (the ***`[Ctrl]`*** key). In this control scheme, the mouse cursor is hidden from view. Any mouse movement directly translates to a corresponding rotation of the game camera (a virtual simulation of a real-world camera that controls what is shown on screen). The sensitivity of the rotation depends on the mouse sensitivity setting in the operating system. To give players an easy way of adjusting the sensitivity, players can modulate the translation between cursor movement and camera rotation at the beginning of the game and by opening the help menu during the game. It should be noted that rotating the game camera happens independently from the player character, as is a custom in many third-person video games. The head of the character instead faces the direction of the most recent locomotion input.

The player character can perform three locomotive actions in the game: walking, running, and jumping. The only additional action is to start an interaction with the master character, which is accomplished by approaching them closely. To perform actions with the player character, players can use just the mouse or involve keyboard inputs. By giving players a choice in how to control the game, *Shinobi Valley* becomes more accessible to a broader audience. Controlling a player character and navigating 3D space, while second nature to many gamers, does not come as quickly to people with less gaming experience or those who primarily play different types of games. Providing two control options increases the chances that players experience a gentle learning curve and can have a more similar gaming experience to one another. Achieving a similar playing experience across players that is not hampered by struggling with the controls is essential for the subsequent data collection and the use of *Shinobi Valley* as an experimental tool. The different input controls are active simultaneously, allowing players to switch between them at any moment as they see fit.

When using both the keyboard and mouse to control the game, players use the ***`[W]`***, ***`[A]`***, ***`[S]`***, and ***`[D]`*** keys to move their character (forward, to the left, backward, and the right respectively). This is frequently the default input control scheme in many 3D entertainment games on PC systems, which is also why it is supported in *Shinobi Valley*. As a variation to these keys, players can also use the arrow keys instead. The ***`[Spacebar]`*** key is used to jump, and the ***`[Shift]`*** key can be held down to run instead of walk. If the player character is controlled with the keyboard, its orientation is independent of the rotation of the game camera.

For players that prefer to only use their mouse, the left mouse button can be held down to start walking. If held for a longer time, the character starts to run automatically and continues to do so until the mouse button is released. The right mouse button can be clicked to jump. If players only use the mouse to control their character, they will lose the ability to move independently from the camera rotation. Holding the mouse button will always move the character forward in the same direction the camera is facing.

In addition to letting players choose how to control the player character, the game provides additional customization options that are frequently found in 3D entertainment games. One option is to adjust the rotation speed of the game camera. Depending on a player's mouse hardware and software settings, the camera might rotate too much or too little when they move their mouse. The game, therefore, features a sensitivity slider that adjusts the amount of camera rotation. Another option is to invert the camera's pitch direction (i.e., up and down). Similar to the direction in which one expects a document to scroll when swiping across a laptop trackpad, people have different preferences in how a game camera turns based on the direction the mouse moves in. Some prefer that the camera rotates up when the mouse moves up, while others prefer the reverse. In many games, as well as *Shinobi Valley*, it is possible to invert the direction to better align with an individual player's expectations. These options can be adjusted as part of the game tutorial at the beginning or accessed in the help menu by pressing the ***`[Ctrl]`*** key. The help menu also allows players to review all possible input controls during the game.

An overview of the game controls and help menu are shown in figure 6.6 as part of section 6.5.

6.3 Camera and Character

Shinobi Valley is a 3D game played from a third-person perspective. In games where the player controls a singular character, players typically see the game environment in one of three ways: first-person view, with an over-the-shoulder camera, and third-person view. A first-person view has the player control the camera as if looking through the character's eyes. Over-the-shoulder places the camera slightly behind the character and, as the name suggests, positions it as if it were over the character's shoulder. In contrast to the first-person view, this view allows players to see their virtual player character. The third-person perspective places the camera further away from the character, showing them within the environment from a certain distance.

The choice of camera perspective can signify a message to the player as to the type of game they will play. For example, a first-person or over-the-shoulder perspective is commonly used in shooter games. Third-person perspectives, on the other hand, can be commonly seen in action-adventure games, e.g., games in which the player solves puzzles, performs platforming challenges, or explores. Naturally, counterexamples exist, and many games offer the option between two perspectives (e.g., first- and third-person), but each perspective has its own prevalent associations as to the nature of the gameplay.

Shinobi Valley utilizes a third-person perspective to make the game accessible to a broad range of players. Not everyone plays shooter games, as they can have a bad reputation outside gaming communities due to their violent content. Secondly, the third-person perspective gives players a clearer understanding of what they can do in the game: jump and explore. Especially jumping in a video game can be challenging from a first-person perspective, as the player cannot gauge distances as easily as when they see the character on screen. Seeing the character on screen can make it easier for players unfamiliar with the controls, or this type of gameplay, to gain sufficient proficiency in a short amount of time.

Finally, the perspective allows players to see the character they are controlling. While in the first-person view, the implied message to the player is that they themselves are inhabiting the world. In the third-person view, the player more easily takes on the role of the character they are controlling. In *Shinobi Valley* this is preferred, as less mental effort is needed on behalf of the player to understand who they are in the game and what their purpose is if they can see the player character on screen.

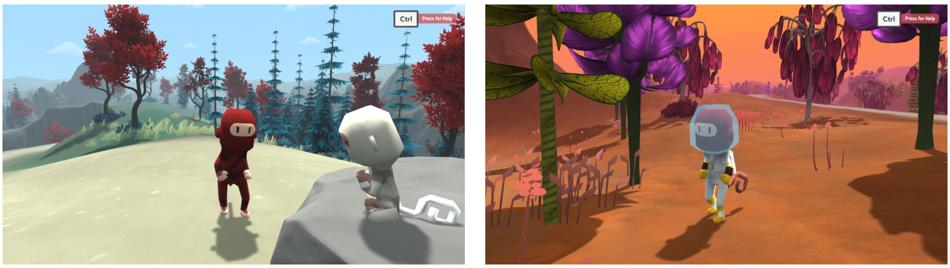


Figure 6.4: Player character and master in their nature aesthetic ninja outfits (left). Alien aesthetic spacesuit still shows parts of the ninja outfit (right).

In the game, players take on the role of a monkey ninja, or “shinobi” in Japanese, en route to meet their master. The visual appearance of these characters is cartoonish, with stout proportions, saturated colors, and simple textures. Depending on the experiment condition, both characters either wear ninja outfits (in the *nature aesthetic* condition) or space suits with helmets over their ninja outfits (in the *alien aesthetic* condition).

The ninja trope has been chosen because it allows involving characters that could conceivably venture out into rough terrain without being impeded by it. Although this characterization is superficial, to have any characterization at all means to involve a narrative element in the game. This, in turn, may cause players to “fill in the blanks” and expand on the limited narrative in their minds (Wesp 2014). While this may enrich the player’s experience, such a minimal approach to storytelling does not rely on high visual fidelity or the creation of explicit narrative content, thus requiring less time and effort to create graphical assets.

6.4 Environment and Game Aesthetics

The game environment in *Shinobi Valley* is designed to invoke a sense of openness and adventure. The terrain is varied and easily accessible regarding the required maneuvering skills. Areas of the terrain not part of the explorable area are indicated by steep and tall cliffs that communicate to the player that they will not be able to overcome them. Players can see roughly half of the total game environment into the distance, with a gradual increase in distance fog to provide a “realistic” limit to how far they can see.

Overall, the game establishes an atmosphere of a whimsical pastiche of ninja tropes. An emphasis is placed on the aesthetic consistency of game elements rather than a high level of detail or invoking a sense of overt realism. The latter is intentionally avoided to prevent players from developing expectations of realistic activities (e.g., the ability to perform acrobatic feats) that the game does not fulfill.

6.4.1 Visual Game Aesthetic

The visual aesthetics of *Shinobi Valley* is marked by bright saturated colors and the use of unusual colors for vegetation. Textures are kept simple and do not involve a high level of detail. Any detail visible in the texture is scaled to make the environment appear large. These visual design decisions are inspired by games such as *World of Warcraft* (Blizzard Entertainment 2004) that involve oversized and cartoonish textures to create a stylized version of real-life textures. In order to keep the game world from appearing too static, all vegetation is subtly animated to give the appearance of a constant gentle wind breeze. The game environment also features moving clouds in the sky for the same reason.

The visual aesthetic that players see in the game depends on what experimental condition is played. The game features two distinctive visual surroundings: a *nature aesthetic* and an *alien aesthetic.* Players only see one of these visual aesthetics during their play session.

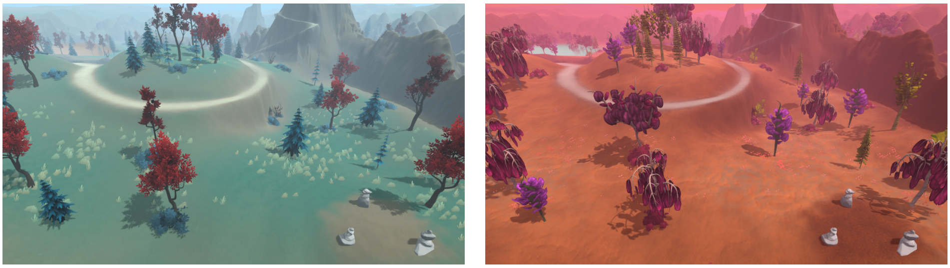


Figure 6.5: Overview screenshots comparing the two visual aesthetics of the game: nature aesthetic (left) and alien aesthetic (right). Note that all elements in the environment retain their location, including trees and bushes.

In the *nature aesthetic* the environment is tinted in green, blue, and brown hues under a blue sky. Bushes and trees approximate the shape and color of actual vegetation, with a reduced level of detail and intense hues compared to real-life examples. In this condition, the player character and the master wear ninja suits.

In the *alien aesthetic* the environment is dominated by red hues with a red-orange sky. Trees feature a wider range of color hues with intense saturation levels and have leaves that resemble insect wings. The vegetation is designed to appear alien yet organic without appearing too threatening or frightening. The player character and the master are shown to wear space suits over their ninja outfits. While the alien aesthetic is designed to match the style of the nature aesthetic closely, it might require a more substantial suspension of disbelief. This is because the game physics is not affected by the visual aesthetic (i.e., gravity remains the same), and the ninja trope is extended with science fiction elements.

Although the in-game visual aesthetic of the game differs depending on the condition, there is no difference in the visual aesthetic of user interfaces (UI). The UI features relatively large text, with longer text passages being broken up over multiple messages that players can progress through. Interactive UI elements are colored in bright orange. Non-interactive parts of the interface are kept in crimson red (the primary color for all interface elements in the game), white, and black. UI elements feature short animations whenever their status changes and in response to input from the player.

Such animations involve short bounces and movements of just a few frames that are meant to draw attention. Video games frequently feature these short animations to provide feedback that an action has occurred. Apart from this utilitarian purpose, they are also considered part of what makes a game feel like a game. Within the game development field, this is referred to as "juiciness" or "juicy design" and means the involvement of elements that are supposed to induce emotional satisfaction in players (Hicks et al. 2018). Juicy animations are particularly common in relatively simple games that are designed for mass appeal (known as "casual games"). This is also an association that is actively fostered in the aesthetic design of *Shinobi Valley*.

Pilot Study Note:
The pilot study features only the nature aesthetic. The alien aesthetic was added to the game after the pilot to consider whether a different visual aesthetic would influence the efficacy of individual design patterns.

6.4.2 Sound Aesthetic

The game features a minimal soundscape with only a few moments accompanied by music. During the game, players can hear atmospheric sounds consisting of subtle wind noises and infrequent interjections of birds chirping. The only other diegetic sound effects in the game are the footsteps of the player character and a short and bright sound effect that emphasizes every jump action. In addition to diegetic in-game sounds, the game features a few non-diegetic sound effects whenever the player interacts with a user interface, as well as a falling sound ending with a "gong" that is played when the player jumps into the bottom of the chasm. Musical emphasis is added at the game's beginning and end, thus acting as a tonal introduction and conclusion, respectively. The music involves primarily Japanese flutes to emphasize the game's premise.

The involvement of sound and music is minimal to suit the ninja trope and be pleasant for as many players as possible. Not having music or sound effects can make a game feel eerie or incomplete. On the other hand, music can feel repetitive or even annoying and needs to be appropriately mixed to not overpower the clarity of sound effects. Sound effects are also limited because players only have a few actions they can take in the game. Consequently, there are only a few moments in which feedback sounds are beneficial to communicate that an action has indeed taken place. Sound effects in the user interface are kept short and are more artificial than other sounds. They differ in their note sequence to give each action in the UI its own identifying sound (e.g., button press feedback, the appearance of dialogue messages, confirmation and progression to a subsequent message, and dismissal of a dialogue message).

Overall, the sound aesthetic in *Shinobi Valley* is designed to communicate the overall premise, provide helpful feedback, sound pleasant to most players, and convey emotional satisfaction by sounding "juicy".

6.5 Tutorial and Help Menu

The game features two systems to ensure that game controls are understood, aid accessibility, and reduce the chance of unintentional confusion for the player. The first is the tutorial game phase, an interactive step-by-step explanation of the game controls at the beginning of the game. Players can only start the game after completing this tutorial. First, players are requested to control the camera to look around. At this point, any other inputs are ignored to ensure that players understand how the camera controls work. After the camera has rotated a predefined amount of degrees around the yaw axis (i.e., left and right), players can progress. This step can be completed in as little as two seconds but is designed to take between 5-6 seconds for most players. In the following step, players are given the option to invert the camera's pitch direction and adjust the rotation sensitivity with a slider.

The tutorial then proceeds with the introduction of the movement controls, i.e., walking and running. Players first receive instructions for how to move their character with keyboard inputs, with a follow-up message that explains mouse-based controls as an alternative input option. Once again, players must show that they have understood how to use the controls by walking until they have left a predefined radius around their starting location. After they have done so, the tutorial concludes by informing players how they can jump and how to access the help menu. Neither of these needs to be proven by the player, given that the game can be completed without jumping, even if some areas are only accessible by doing so. With the tutorial completed, players are free to go anywhere in the game.

The second system aiding players is the help menu. It can be accessed during the game to review the control scheme, adjust the camera movement sensitivity, and invert the pitch axis (similar to how the scroll direction can be changed on computers to accommodate different user preferences).

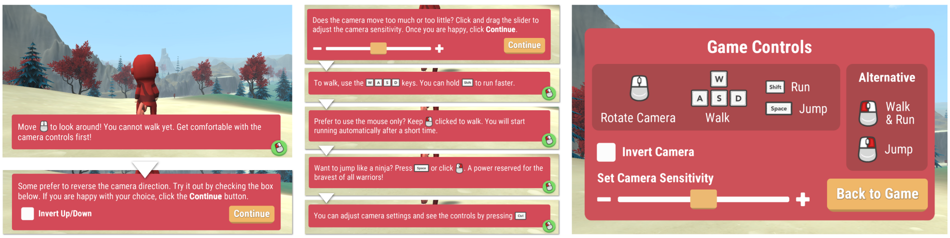


Figure 6.6: Screenshot sequence of the tutorial steps explaining game controls (left and middle). Screenshot of help menu and access to accessibility settings (right).

6.6 Game Technology

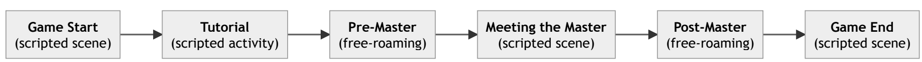
Shinobi Valley is developed with the *Unity* game engine (Unity Technologies 2018). The game is developed for WebGL deployment but can also be deployed for PCs running *Windows* or *macOS*. Most of the game code and assets are created specifically for this study. Some proprietary "middleware" packages are used to shorten the development time and increase the game's fidelity. Middleware includes voxel-based terrain shaping tools (Amandine Entertainment 2019; Roland09 2019), terrain painting tools (Procedural Worlds 2019), procedural texture creation (Filter Forge Inc. 2019), and a boiler-plate character controller for a humanoid third-person player character (Invector 2019).

In addition to the *Unity* part of the game, the game client, *Shinobi Valley* also consists of a server component written in PHP and MySQL. The server component is responsible for collecting player data generated by the client. All communication between the client and server is encrypted using 256-bit AES encryption with random IV generation. To ensure that the server is not overwhelmed with connection requests, all data is cached and submitted in a 5-second interval. The cache is only emptied upon receiving a confirmation from the server and is otherwise concatenated into the next submission cache to ensure that play data is not lost. This can lead to data being logged twice if the client did not receive the server's confirmation, but the data was successfully logged. Duplicate log entries created this way are merged based on matching millisecond time stamps during the post-processing of play data. Likewise, missing entries are flagged based on gaps in time stamps, given that game events are logged at pre-determined intervals.

The game only loads if a connection between the client and server can be established but does not interrupt an ongoing play session if the connection is lost later. In this case, the game continues attempting to submit the cached data at the pre-set 5-second interval. If a player terminates a play session and restarts the game, the server treats this as a new play session. In other words, players cannot continue an incomplete play session at a later time.

6.7 Game Phases in Chronological Order

In the game, players go through different phases that impact both whether they can control the player character and their understanding of the situation they are in. These phases always occur in the same order, without the possibility of returning to an earlier phase. The duration of phases depends on the player, but some involve fewer activities than others. The phases are:



1. **Game Start:** Presents information about the game's premise.
2. **Tutorial:** Provides an interactive explanation of game controls.

3. **Pre-Master Play:** Players are free to explore the game environment until they approach the master at the end of the primary path.
4. **Meeting the Master:** A short message dialogue informs players that their master is still meditating.
5. **Post-Master Play:** Players are again free to explore the environment until the master has finished meditating and is approached by the player again.
6. **Game End:** A short non-interactive sequence plays out, and players are thanked for playing.

Gameplay information described up to this point in the chapter has been primarily about pre-master and post-master phases, as this is where players are free to take control over their player character. These phases also take up the majority of the playtime. The following sub-sections outline some of the phases in more detail, especially concerning restrictions or impacts on the free exploration of the game environment.

6.7.1 Game Start

At the start of the game, players are greeted with an introduction screen reminding them to play without interruption and wear headphones or play in a quiet environment. Once they press the start button, the game will load and open up to show the player character for the first time. At this point, the player character is already positioned on the primary path and faces the direction in which it is headed.

One of the experimental conditions is whether or not players are given an explicit goal in the game. This is further outlined in Chapter 7. In short, players are either given an explicit goal with some narrative context or enter the game without either.

In the explicit goal condition, the game introduces the player character and what lies at the end of the player's path. This is followed by a short camera sequence or "cutscene", in which players get a preview of the entire path. The preview consists of three slow camera pans along the path toward its destination. In these sequences, players can also see several wooden signs pointing toward the end destination. These are meant to ensure that exploratory behavior of players is due to their intention rather than confusion. Once the camera sequence concludes, the camera returns to focus on the player character, and the tutorial begins.

For players that play in the implicit goal condition (thus lacking an explicit goal), the game starts directly with the tutorial. There is no introduction about the player character, what awaits them at the end of the path, or a cutscene preview of it. Likewise, there are no wooden signs indicating the direction of the destination.

> **Pilot Study Note:** In the pilot study, all participants play in the explicit goal condition.

6.7.2 Meeting the Master and Post-Master Play

Once players have reached the ninja master at the end of the path, they will find them in a meditation pose. The game displays a text message informing the player that the master will still be in mediation for some time. In most cases, the message will tell players to return in “5 minutes or so”. If players have already played for more than 10 minutes before meeting the master, the message will tell them to come back in “2-3 minutes or so”. This time reduction is meant to unburden players who have already spent much time in the game.

If players approach the master again before the waiting time is up, a short message will remind them how much time they will still have to wait. Players are not given an exact time measure but instead are told to come back in “5 minutes”, “3-4 minutes”, “2-3 minutes”, or “a minute”, depending on how much time has passed. The waiting time is part of the game to capture player behavior when the question of what can be found at the end of the primary path is answered, and all players can do is wait.

Players are not given the exact timing down to the seconds to avoid focusing their attention too strongly on their timing. This is meant to make exploration more attractive than waiting for something to happen. Naturally, how players behave in this game phase is not comparable to how they behave before they meet their master. While the upcoming chapter will address this point in more detail, it is essential to note that the exploration that occurs after meeting the master is, at least in part, the result of alleviating boredom.

Once the waiting time has passed, the master will get up from their meditation pose and wait for the player to approach them. This means players can take as much time as they want to explore the game environment. The game does not inform the player that the waiting time has run out. Players can only find out by looking at the master (to see them in a different pose), and approaching them, which triggers the last game phase.

Pilot Study Note:
During the pilot study, waiting time was not reduced for players who had already spent much time exploring. The results of the study motivated this implementation.

6.7.3 Game End

After the master has finished meditating, players can approach them to initiate the end of the game. At this point, the master will greet the player with the following words (numbers indicate separate message boxes in sequence):

> (1) Oooh! There you are! We have awaited your arrival most impatiently.
> (2) Come, join me in meditation! Share with me the stories of your travels … in silence!

Afterward, the game shows a cutscene of the player character and the master meditating, ending with a fade to black. The game then shows a final information screen, thanking players for playing and informing them that a message box will open that brings them to the post-play survey (described in more detail in Chapter 7).

6.8 Pattern Integration

This section describes the integration of the design patterns hypothesized in Chapter 5 and meant to be evaluated through *Shinobi Valley*. One of the fundamental challenges of formulating design patterns for video games is that they need to be balanced in their scope. A pattern should not be defined with too much specificity, as it can become too descriptive of specific implementations. Design patterns are most valuable when they generalize to a wide range of similar circumstances. On the other hand, formulating such patterns too vaguely can make them more challenging to adapt to a given use case. *Shinobi Valley* presents a case study of how patterns to elicit curiosity for spatial exploration can be implemented. By describing the design considerations that go into the integration of each individual pattern, the game serves as an applied example for future implementations and related investigations.

Within *Shinobi Valley*, each hypothesized design pattern is implemented at three different locations and is positioned in such a way as to avoid clustering similar patterns too close to each other. Each location is referred to as a PIR. All PIRs are communicated visually as part of the topology and architecture of the environment. It would have been possible to emphasize the characteristics of the virtual space through how it reflects sound and thus acoustically communicate patterns. However, doing so would have introduced the need for stricter control over the acoustic environment in which players play. Instead, *Shinobi Valley* focuses on the *visual representation of design patterns.* The individual implementations of these patterns can differ in how prominent they appear to players. This is difficult to quantify, as it depends greatly on a player's location and camera perspective at any given time. To give an example, a player who aims the camera in a way that shows only the ground will have a harder time noticing the mountains. As a result, while each pattern is placed with the design intent to draw attention to itself under certain circumstances, the realization of that intent depends on the player's moment-to-moment decisions within the game environment. This section describes the design intent concerning the placement and design of the individual PIRs.

Pilot Study Note:
During the pilot study, participants who visit a PIR for the first time hear a gong sound effect and see a brief wind swirl of red leaves around themselves. This is meant to indicate to them that they have been successful in discovering a place of interest and provide positive reinforcement. This feature has been removed from the game for the subsequent study. Although games frequently provide similar feedback to players, it would have made it difficult to discern whether continued exploration results from a curiosity for features in the environment rather than collecting as many positive reinforcement cues as possible.

To not bias participants, the arrangement of the individual regions is designed to be diverse. Individual regions are not emphasized beyond the properties that make such regions examples of design patterns to elicit a desire for exploration. At the same time, the environment of *Shinobi Valley* was designed to appear as it would in other video games. Designing the environment with too strict parameters might result in players focusing on the artificial nature of the layout. Instead, the play direction is considered as a way to control for potential order effects in the environment design of *Shinobi Valley*.

An S-shaped primary path connects two areas in the environment. Informally, and unbeknownst to players, one area is labeled "A" while the other is labeled "B". The play direction condition is then defined by the direction that the game is played: either A→B or B→A. The map of *Shinobi Valley* is designed to be reversible in spatial layout and PIR placement. When playing the game, players are randomly assigned to play the game in one of the two play directions. While the exposure of individual PIRs is expected to be impacted by play direction, the overall impact of PIRs should not be affected.

The master character and the stone they are sitting on change location depending on the play direction, with the player character starting the game in the opposite area. Depending on the game condition, they will also see wooden signs pointing toward their target destination. The placement of these signs is always the same, but the direction in which they point depends on the whether participants play from A→B or B→A.

6.8.1 Pattern: Reaching Extreme Points (EXP)

Three tall mountains in the game environment use the design pattern of reaching extreme points: one at each end of the primary path and one approximately at the midpoint. Each mountain can be climbed by taking a narrow path with several hairpin turns to the top. By the very nature of their shape, mountains stand out as visual landmarks from most locations and perspectives in the game environment. The environment in *Shinobi Valley* is generally designed as a mountainous area and thus features cliffs as boundaries and a long mountain range that separates the playable area. It is not only the extremity of a landmark that makes it a pattern for spatial exploration but also the intentionally shaped perception in the player that it is indeed reachable.

In *Shinobi Valley* this perception is encouraged by having a visually distinctive path leading up to the top of the mountain. Depending on the player's location, the path can be seen from a long distance away. Its shape, relatively gentle angle of incline, and coloring communicate to the player that it is an intentionally created pathway to the top and,

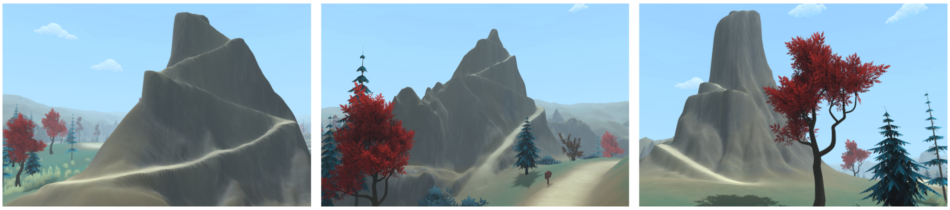


Figure 6.7: Screenshots from the three instances of the *extreme points* (EXP) pattern. Instances are labeled (left to right): *Mountain A*, *Mountain B*, and *Mountain C*.

thus, that the extreme point it leads to should be thought of as part of the explorable game environment.

Extreme points could have been implemented in other ways, such as involving tall artificial structures or areas surrounded by obstacles that threaten the player (e.g., a location surrounded by spikes). In many video games that let players roam freely, height is a threat, as the player character can be incapacitated through fall damage. In *Shinobi Valley* the only threat or punishment for falling is in the time it takes to reach the spot again, as walking up a mountain path takes time and requires somewhat precise maneuvering of the player character. Given that the game does not involve any simulated threats to the player character's health, tall mountains were chosen as the most fitting implementation of this pattern.

It should be noted that the chasm in the game environment can also be thought of as an extreme point. While the chasm has been designed to act as a natural boundary, players in the *Shinobi Valley* pilot study investigate it by jumping into it more than once. This illustrates that intentional signaling regarding what areas make up the explorable part of a game environment can be challenging. Video games typically involve a combination of techniques to guide player movement. This is done through real-world metaphors (the danger of falling from great heights) and following video game conventions (e.g., the player character seemingly remarking to itself that it does not want to go where it is steered to).

In many cases, a game can establish a convention at the beginning that involves only minor consequences to establish a vocabulary for guiding player behavior. As such, players would likely refrain from jumping into similar chasms after players had the opportunity to verify that the game does not consider them as explorable spaces. Nevertheless, this is a cautionary example that some parts of a game environment might be understood as design patterns without the designer's intention.

6.8.2 Pattern: Resolving Visual Obstructions (OBS)

The pattern of resolving visual obstructions is integrated into the game environment in two ways: two dense forest areas and one area with thick ground fog. Each forest area is located towards the first and last third of the primary path, while the area with ground fog is roughly at the midpoint of the path. These three implementations are roughly similar in the amount of space they occupy in the game environment but differ in how they stand out.

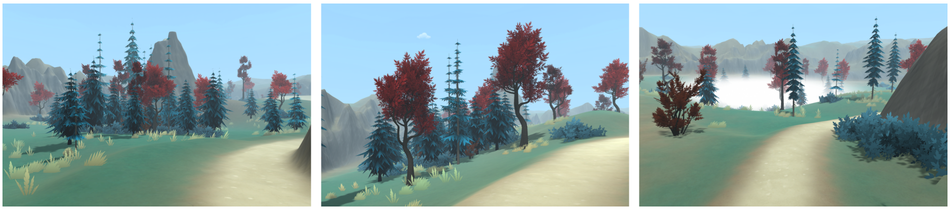


Figure 6.8: Screenshots from the three instances of the *visual obstructions* (OBS) pattern. Instances are labeled (left to right): *Forest A*, *Forest B*, and *Ground Fog*.

Forest areas create visual obstruction through occlusion due to a high density of vegetation, with small gaps of visibility meant to communicate that players can traverse these areas. On the other hand, the area with thick ground fog stands out by its bright white appearance. Visibility is completely obstructed, and it is instead the nature of the obstruction that communicates that exploration is possible. Fog may severely reduce visibility but does not impede a player's abilities. An essential aspect of the implementation of these areas is that they must be understood as active parts of the game environment by players of the game. Visual obstructions in video games are frequently not simply visual but also actual barriers that restrict the movement of a player character. Game environments are finite and often tightly limited to predefined paths. Whereas some games involve invisible borders in the sense that movement may be restricted without an apparent, in-game rationale, many games create a diegetic context for why movement is limited.

The visual design of such barriers communicates a different message than the one communicated by visual obstructions that can be resolved. Barriers need to appear insurmountable so that they do not elicit players' curiosity. After all, players will be unable to satisfy their curiosity, which creates a moment of disappointment and possibly weakens their suspension of disbelief, at least momentarily, if a game barrier lacks any diegetic rationale. This is also why the explorable area in *Shinobi Valley* is bounded by cliffs. The intention here is to let players know that while they can climb some mountains (either through a path or ledges that can be jumped on), they cannot climb this particular mountain cliff.

Visual obstructions that can be resolved need to strike a balance between creating an area that cannot be fully understood from afar and an implementation that suggests that players can do so by exploring more closely. In *Shinobi Valley* this happens through the material that is chosen to build such areas (both forests and fog are fundamentally permeable in the game), as well as their location. All three areas are situated entirely within the explorable area, with some distance from the boundaries of the game environment. The placement of OBS instances provides additional evidence to players that these areas can be explored if they choose to do so.

6.8.3 Pattern: Out-of-Place Elements (OOP)

The pattern of out-of-place elements is integrated through three ostensibly artificial structures in an otherwise natural environment. Two instances of the pattern consist of a trio of stacked stones arranged in a triangle formation. The third instance is a stone monolith with a stone spiral surrounding it. Apart from the stone formations, the ground color on which they rest is distinct from the surrounding environment, giving further emphasis to the location when seen from afar.

In the context of *Shinobi Valley*, OOP instances appear to indicate places of cultural significance purposefully. While every detail in a game is artificially created by its very nature, the difference for OOP instances is that they appear artificial in the context of their immediate surroundings. A cave on a mountain cliff may attract curiosity, but it is not a surprising feature of the landscape in *Shinobi Valley*. If, however, the game were to take place in a city environment, a hill with a cave next to a row of houses should elicit curiosity as part of the out-of-place pattern.

Figure 6.9: Screenshots from the three instances of the *Out of Place* elements (OOP) pattern. Instances are labeled (left to right): *Stone Spiral*, *Stone Stack A*, and *Stone Stack B*.

In the context of video games, players are also likely to form expectations when encountering similar objects close to one another. Such objects are frequently part of small cognitive challenges. This notion is further emphasized by having three stone stacks nearby, given that the number three is frequently used in game mechanics. Examples include creating order among three elements, finding a unique difference in one of three objects, or repeating an action three times to defeat an enemy.

On the other hand, the stone spiral instance is designed to focus attention toward a specific point of interest: in this case, the monolith at its center. This is akin to discovering a large “X” in the landscape, seemingly indicating the location of a treasure or a landing zone.

All OOP instances in the game are based on purposefully arranged stones as if conscious inhabitants of the world placed them. They are meant to communicate to the player that their character is part of a society that has marked something important. As with all elements in a game, players may experience this as a communication attempt by the game designer. However, by using diegetic game elements for this communication, players are more likely to sustain a state of suspended disbelief.

6.8.4 Pattern: Understanding Spatial Connections (SPC)

The pattern of understanding spatial connections is integrated into the environment as two cave systems and a path leading to a hill plateau. As is the case for other patterns, their location is distributed across the primary path, with two implementations closer to the ends of the path and one closer to the midpoint.

In contrast to other patterns discussed so far, spatial connections are more difficult to pin to a specific location. After all, the term implies the involvement of at least two places that are connected in space. In *Shinobi Valley* this pattern provides a clear view of a location without an apparent explanation for how this location can be reached. The path that leads players to each of the three locations is relatively hidden and thus requires them to actively look for a way to get there. The path that leads players to their destination, i.e., the connection aspect, is less important than the question of where such a path might exist. Once the path is found, the question is answered, and their curiosity is likely satisfied. On the way to the location, players might wonder whether the connection is getting them to where they think it should lead them, or they might look forward to the intrinsic reward of having reached the place that has elicited their curiosity.

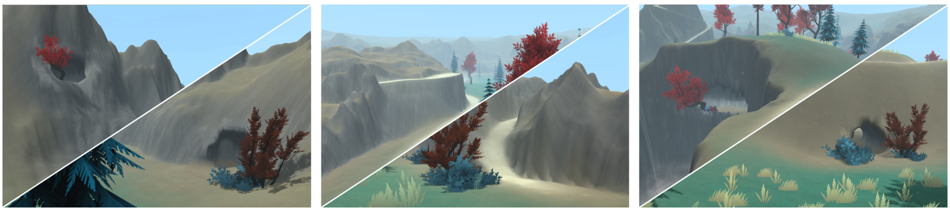


Figure 6.10: Screenshots from the three instances of the *Spatial Connections* (SPC) pattern. Instances are labeled (left to right): *Mountain Cave*, *Hill Path*, and *Cliff Cave*. For each, the left half shows the more visible part of the instance, and the right half shows the more hidden connection that provides access.

Both cave systems have a more prominent side that is supposed to attract attention. That side is either on a cliff side or the side of a mountain and cannot be reached from where players can see them. The caves feature trees that grow out of them to attract players' attention. The hill plateau stands out due to using the same texture as the primary path, despite not being connected to it. Players are invited to wonder about how that part of the path can be reached. For each instance, the part that allows players to reach the location attracting their attention is less visible and covered in slightly denser vegetation.

The challenge of implementing this design pattern is that it can elicit curiosity without being part of the SPC pattern. Players might stumble upon a cave entrance without encountering the part that is supposed to be more visible. Especially the *Hill Path* PIR is more visible from one side of the game environment than the other. This means that players might encounter the "solution" to their curiosity before encountering the part that is supposed to elicit it. Players might also have had their curiosity elicited but never find out how to reach their desired location, and thus give up on it eventually.

6.8.5 Pattern: Desired Objects Foraging (DOF)

Games often reward players for collecting specific objects, but such objects may also be used as motivators for exploration. *Shinobi Valley* uses bananas as objects of desire for the player to collect. These are functionally the same as coins in many other games, representing something of value to the player character.

In contrast to other instances, the DOF pattern is implemented at five locations. Two of them are placed directly on the beginning and end of the primary path to inform players about their existence. Picking these up also allows players to see that nothing else happens as a result of collecting bananas. The remaining three banana instances are thus more likely to be collected as part of the foraging motivation rather than to find out what happens when bananas are picked up.

The player character needs to touch bananas to pick them up. This causes their visual representation in the game world to disappear. No further action occurs, and players can also not collect the same banana anymore.

> **Pilot Study Note:**
> This pattern was only featured in the pilot study. It was taken out of the game for reasons that are further elaborated on in the discussion section of this chapter.

6.9 Pilot Study

A pilot study with 24 participants was conducted to assess the efficacy of *Shinobi Valley* as an experiment tool. Participants were recruited through convenience sampling in a University environment, with all having previous experience playing video games.

In this first part of the two-part study, the question at hand was to evaluate whether design patterns motivated players to leave the primary path. To answer this question, sub-questions had to be answered regarding the quality and stability of the game as a research tool. To do so, players filled in a post-play survey after completing the game.

The post-play survey included the following:

- **Demographic data:** age and gender
- **Gamer type self identification:** "Expert", "Core", "Casual", or "Novice"
- **Frequency of playing video games:** Indication of hours per month
- **Validated game experience questionnaire:** assessment of game quality
- **Open questions and comments:** Free-text answers on questions of why players did or did not leave the path, as well as positive and negative aspects of the game

The following sub-sections elaborate on the questionnaire used in the survey, sampling, procedure, and pilot study results.

6.9.1 GUESS Questionnaire

In order to assess how participants experience the game, the *Game User Experience Satisfaction Scale* (GUESS) is included as part of the post-play survey. The GUESS (Phan, Keebler, and Chaparro 2016) has been developed to assess user experience satisfaction and provide insight into players' attitudes and preferences. It consists of 55 rated statements divided over nine sub-scales. The following list and description of the sub-scales are taken from the original publication:

1. **Usability / Playability:** The ease with which the game can be played with clear goals/objectives and with minimal cognitive interferences or obstructions from the user interfaces and controls.
2. **Narratives:** The story aspects of the game (e.g., events and characters) and their abilities to capture the player's interest and shape the player's emotions.
3. **Play Engrossment:** The degree to which the game can hold the player's attention and interest.
4. **Enjoyment:** The amount of pleasure and delight the player experienced due to playing the game.
5. **Creative Freedom:** The extent to which the game can foster the player's creativity and curiosity, and allows them to express their individuality as part of the game.

6. **Audio Aesthetics:** The different auditory aspects of the game (e.g., sound effects) and how much they enrich the gaming experience.
7. **Personal Gratification:** The motivational aspects of the game (e.g., challenge) that promote the player's sense of accomplishment and the desire to succeed and continue playing the game.
8. **Social Connectivity:** The degree to which the game facilitates a social connection between players through its tools and features.
9. **Visual Aesthetics:** The game's graphics and how attractive they appear to the player.

The number of rated items per sub-scale varies between three and eleven items. Each item presents a statement that inquires to what extent participants agree on a 7-point rating scale. Each point on the scale is named and corresponds to a score: (1) "Strongly Disagree", (2) "Disagree", (3) "Somewhat Disagree", (4) "Neither Agree nor Disagree", (5) "Somewhat Agree", (6) "Agree", and (7) "Strongly Agree".

The average score within each sub-scale corresponds to the overall score of that sub-scale for the assessed game. The average score of all sub-scales is combined to score the game as a whole. The authors of the GUESS have demonstrated that it can be administered to participants with varying gaming experience and can be used to evaluate different types of video games.

In the *Shinobi Valley* pilot study, participants rate a total of 44 statements of the GUESS, providing results for seven sub-scales: "Usability/Playability" (11 items), "Play Engrossment" (8), "Enjoyment" (5), "Creative Freedom" (7), "Audio Aesthetics" (4), "Personal Gratification" (6) and "Visual Aesthetics" (3).

The sub-scales "Narratives" and "Social Connectivity" of the GUESS are excluded because the game does not involve such elements, or at least not to the extent that would justify their inclusion.

Usability and aesthetics are essential to assess whether the game experiment can fulfill the expectations that participants have when playing a game. Low ratings in usability could mean that player behavior is not due to intentional actions but rather the result of struggling with the technology. Likewise, the simulation of a game experience requires that participants also perceive the game as a game. Aesthetics play an essential part in that heuristic, as is evident by its inclusion in the GUESS.

The order of statements in the GUESS section of the survey is randomized for each participant.

6.9.2 Sampling and Procedure

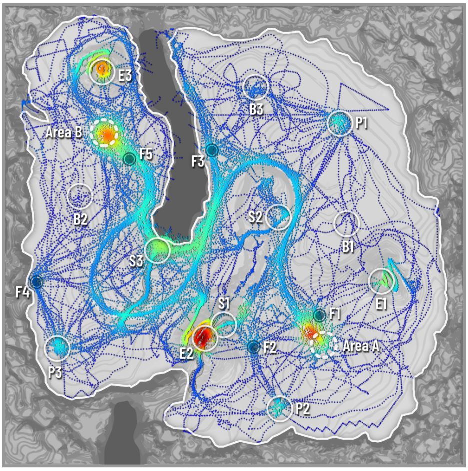
Participants were recruited through convenience sampling (Marshall 1996) from the University environment. The focus in this first part was to acquire data in a short amount of time and thus sample from a population that is accessible without more exhaustive recruitment efforts. The game and subsequent questionnaire were accessed through a dedicated website, which first showed general information about the experiment and the consent form. When accepted, players were then directed to the game.

As mentioned throughout the chapter, the pilot study participants played the same experiment condition. The game featured an explicit goal statement, five hypothesized design patterns (each with multiple instances), and used the nature aesthetic. Participants were randomly assigned to one of two play directions to counter-balance order effects in the presentation of design patterns. A change in the play direction means switching the starting location of the player character and the ninja master around. This also influenced the direction of the wooden signs along the path, which would always point towards the direction of the ninja master, i.e., the explicit goal destination.

Some participants took part in the pilot in a lab setting so that the researcher could observe their gameplay and uncover any potential issues, e.g., technical errors or problems in understanding the experiment. For lab participants, a researcher was present throughout the experiment, positioned so that participants could contact them in case of questions, but without overlooking them from behind nor being in their peripheral view during the experiment.

In the lab setting, participants were asked to annotate a video recording, created automatically by the game when used in this setting, with how curious they felt during play. This was done with a modified version of the affect rating tool *CARMA* (Girard 2014) and an analog trigger that participants were instructed to squeeze to indicate higher curiosity. Depending on how far the trigger was squeezed, a higher value was recorded and time-stamped based on the video recording for subsequent evaluation. When playing in the lab setting, participants thus took longer to complete the experiment, as they re-watched their playthrough and annotated the curiosity they experienced through the analog trigger.

The purpose of including post-play affect ratings was to assess player curiosity at different moments in the game and to consider whether this method of acquiring data could be used in the more extensive study.



	Pattern Instatiation Region (PIR)	% of players	Time Spent [sec]
EXP	**E1:** Mountain A	41.7	11.6
	E2: Mountain B	75.0	22.0
	E3: Mountain C	66.7	13.5
OBS	**B1:** Forest A	12.5	7.2
	B2: Forest B	20.8	4.1
	B3: Ground Fog	66.7	3.5
OOP	**P1:** Stone Spiral	62.5	6.3
	P2: Stone Stack A	41.7	15.7
	P3: Stone Stack B	75.0	7.2
SPC	**S1:** Mountain Cave	45.8	4.0
	S2: Hill Path	50.0	4.1
	S3: Cliff Cave	66.7	9.4
DOF	**F1:** Banana A	75.0	–
	F2: Banana B	62.5	–
	F3: Banana C	91.7	–
	F4: Banana D	79.2	–
	F5: Banana E	100	–

EXP — Extreme Points
OBS — Visual Obstructions
OOP — Out of Place Elements
SPC — Spatial Connections
DOF — Desired Object Foraging

Figure 6.11: Heatmap showing an aggregate of all participant movements (left). Longer durations or overlapping movement paths are indicated by changing the hue from dark blue via green to dark red. A table of all PIRs (right) shows the percentage of players that have visited a PIR and how much time participants spent there on average.

6.9.3 Results

A total of ***24*** participants completed the game. Play sessions lasted for a mean of ***Mn=12.12*** minutes (***SD=4.8***). The random allocation of play direction resulted in ***15*** participants heading A→B (***62.5%***) and ***9*** heading B→A (***37.5%***). Out of ***24*** participants, ***22*** completed the post-play survey. The mean age was ***Mn=27.4*** (***SD=8.96***), with ***9*** players identifying as female (***41%***) and ***13*** identifying as male (***59%***).

The majority of players self-identified as "Core" players (*n=9*, *41%*), with *Mn=2.36* (*SD=0.93*) if converted to a scale from 1 ("Expert") to 4 ("Novice"). The majority of players reported playing between 10-20 hours per month (*n=7*, *31.8%*), with *Mn=2.73* (*SD=1.14*) if converted to a scale from 1 ("Less than an hour per month") to 5 ("more than 40 hours per month").

Player metrics were processed to create a heat map for each player (see figure 6.11 for an aggregated heatmap of all players). All PIRs were visited by multiple players, with both forest regions (instances of *Visual Obstructions* or OBS) being the least visited (*n=3*, *12.5%* and *n=5*, *20.8%* respectively) and both *Mountain B* and *Stone Stack B* being the most visited (*n=18*, *75%*). Every participant collected one instance of the *Desired Object Foraging* (DOF) pattern, with the least collected instance still being collected by *15* (*62.5%*). A total of *16* participants (*66.7%*) jumped into the chasm separating two sides of the primary path, out of which *11* (*45.8%*) did so at least twice. Most such jumps took place at the *Cliff Cave* PIR, indicating that at least some jumps are not intentional but a result of entering the cave from its visible side rather than the connected hidden entrance.

Results of the GUESS survey are assessed on a Likert scale from 1 (worst) to 7 (best). Mean ratings were above the midpoint in all categories:

- Audio Aesthetics: *Mn=6.21* (*SD=0.63*)
- Creative Freedom: *Mn=5.15* (*SD=0.75*)
- Enjoyment: *Mn=5.18* (*SD=1.01*)
- Personal Gratification: *Mn=5.05* (*SD=0.89*)
- Play Engrossment: *Mn=4.78* (*SD=1.03*)
- Usability: *Mn=5.83* (*SD=0.57*)
- Visual Aesthetics: *Mn=6.12* (*SD=0.71*)

Kendall's Tau-b (τ_b) correlations of survey results show three significant correlations (at $p<0.05$). Play frequency is correlated with gamer type self-correlation ($\tau_b=0.64$, $p<0.001$) and is inversely correlated with the *Play Engrossment* (PE) score ($\tau_b=-0.43$, $p=0.01$), while participant age correlated with the usability score ($\tau_b=0.34$, $p=0.039$).

Open-question results and comments left at the end of the survey indicated that the game's visual quality left favorable impressions. At the same time, the lack of challenge was experienced as unfavorable. Participants indicated leaving the path to explore the surrounding environment, noting various PIRs that stood out to them. Comments also mentioned the collection of bananas as a motivation for leaving the path. Participants who had explored the environment before talking to the ninja master commented on being annoyed at waiting without much to do.

6.10 Discussion

The focus of the pilot study was to assess the suitability of *Shinobi Valley* as a research environment for part two of the study. Before the study, it was unclear whether players would explore without being specifically prompted by the game. To make any possible exploration behavior surface as the result of curiosity, instructions in *Shinobi Valley* only related to controls and the goal of reaching the ninja master. Exploratory behavior was shown by all participants and for all PIRs, suggesting that the patterns successfully elicit curiosity for spatial exploration.

The average playing time of 12 minutes suggests that players generally spent more time exploring than would be expected if their motivation was to complete the game as fast as possible. Based on which PIRs were visited, there are indications that some patterns and instances are more successful in eliciting curiosity in players.

Players rated the game positively, with GUESS ratings averaging above the mid-point. The lowest and most contested measure was that of *Play Engrossment* (PE). The items in this category relate to whether the player felt detached from their physical environment during play or from real-world events, e.g., time. PE is the only category in the GUESS that showed a significant correlation with another item in the questionnaire: play frequency. It can be hypothesized that the lack of challenge reported by players contributes to the differences in the score, resulting in lower scores from participants who spend more time with and are likely more skilled at playing games. Despite this, the overall score is still above the mid-point, and the other measures indicate that the game is of sufficient quality to provide a suitable experiment environment for a more comprehensive study.

Although the evaluation of the game was positive, certain factors will be different in the experiment as opposed to the pilot. The experiment involves a larger sample size and, thus, controls for contributing factors. Components of the GUESS questionnaire are used again, although those related to the game's quality (e.g., audio and visual aesthetics) are removed as the game's aesthetic quality is sufficiently assessed by the pilot study. It is also important to note that, while the game was well-received by pilot participants, they were recruited through different means than those in the experiment (online and anonymous recruitment, rather than convenience sampling and personal approach). This may cause a difference in game reception and willingness to invest time playing.

6.10.1 Changes Based on Pilot Study Results

Apart from assessing the suitability of *Shinobi Valley*, the pilot study also motivated several changes to the game based on participant feedback:

Removal of the *Desired Objects Foraging* (DOF) pattern: This pattern has been the most "attractive" in the pilot study but has also been perceived as a motivation that is difficult to classify as spatial exploration. Once players know that objects can be foraged for, they might be primarily motivated by collecting as many as possible or form expectations as to what might happen if they reach a certain number. In the context of a larger game, this can be desirable and combine well with other patterns. However, for experimental purposes, it makes it more challenging to attribute explorative behavior to the nature of individual patterns.

Removal of audio-visual feedback when visiting a PIR for the first time: Similar to DOF patterns, the audio-visual feedback of encountering a PIR for the first time could motivate players to "collect" all PIRs. Although this can be desirable in many games, it is not ideal for experimental purposes. This removal might reduce enjoyment, as a lack of game feedback can make the game feel less engaging. However, it makes player behavior easier to assess and attribute to curiosity for exploration based on individual patterns.

Reducing the waiting time by half if players have played for a long time: Since participants take the GUESS questionnaire only after playing the game, their last impression of the game likely affects their scores. Participants who have explored a large part of the game before meeting the ninja master are thus more likely to end their experience in boredom, which can affect overall scores. To mitigate this impact, the waiting time is thus reduced for players that have already played for a long time.

Dropping in-person testing and related measures: Although in-person testing worked well during the pilot study, the more extensive study had to be carried out during the first SARS-CoV-2 pandemic. Measures that were taken only in the lab, specifically participants' affective state over time, were replaced with short in-game surveys.

6.11 Conclusion

This chapter described the design and implementation of five design patterns meant to elicit curiosity for spatial exploration. The research question raised in the chapter has been addressed through a pilot study. The contributions of this chapter are twofold.

First, it shows, by example, the process of implementing and evaluating design patterns for empirical study. It highlights the many considerations that need to be considered in this process, both from a game design and a research standpoint. In doing so, the chapter answers the primary research question: *How can design patterns for exploration be implemented and evaluated for empirical study?* The process, methods, and procedures described in this chapter can serve as a basis for future work where other patterns are implemented for similar purposes.

Secondly, the example case study described in this chapter specifically examined design patterns for spatial exploration. Based on the results, the research questions examined by the pilot study can be answered thus:

1. The implemented level design patterns motivated players to go out of their way to explore them.
2. The quality of the game can be considered sufficient, given above mid-point ratings from a validated game experience questionnaire and positive participant feedback. The pilot study revealed a need for some adjustments implemented in response.

3. The logging system and subsequent survey captured enough data to evaluate player behavior. The pilot study did not reveal a need for capturing additional data.
4. The game operated reliably throughout the pilot study.

Based on these results, the next chapter describes the second half of the study: the empirical evaluation of level design patterns.

7 Empirical Evaluation of Level Design Patterns

This chapter describes the empirical evaluation of level design patterns for spatial exploration. To facilitate this evaluation, the research game *Shinobi Valley* was designed, developed, and piloted (Chapter 6) based on hypothesized design patterns (Chapter 5), following observations from games that elicited curiosity from players (Chapter 4).

> The research question that guides the work in this chapter is:
> **How do design patterns for exploration influence player behavior and experience?**

Although designers have an intuitive sense that curiosity is an important factor of game design (Schell 2008; Costikyan 2013; Klimmt 2003), how it can be purposefully elicited is not obvious and has not been studied empirically. This is unfortunate, as a more evidence-based understanding of what design features elicit the desire to explore would provide a stronger foundation for the research of player experience. It would also benefit the practice of game design and the development of engaging procedural environments.

The study presented in this chapter aims to perform fundamental work in filling this research gap. It assesses the impact of four level design patterns that are integrated through twelve individual implementations (three for each pattern). The four implemented patterns are:

- Overcoming *Extreme Points* (EXP) such as mountain peaks or other hard-to-reach structures

- Resolving *Visual Obstructions* (OBS) in the environment to discover what they might hide
- *Out-of-Place Elements* (OBS) that appear to not 'fit' into the environment
- *Understanding Spatial Connections* (SPC) between areas in the game environment

The expectation is that an environment purposefully designed to stimulate exploration causes players to behave differently and regard the environment more positively.

In the study, exploration is measured by the combination of in-game actions (i.e., game metrics) and players' accompanying emotional investment (through a post-game questionnaire and self-reported emotion words during gameplay). The gameplay is divided into a period of free exploration and one where participants must wait before completing the game.

This study aims to evaluate the following hypotheses:

- **H1a:** Level design patterns elicit more exploratory behavior from players
  H1b: Presence of level design patterns positively affects the emotional experience of the game
- **H2:** Having an explicit goal reduces exploratory behavior
- **H3:** Players with a higher predisposition for curiosity engage in more exploratory behavior

The study of level design patterns is the primary focus of the presented study and is what motivates the two H1 hypotheses. However, some aspects implicit in a video game can also influence exploration. For example, many games have a stated goal (a "main quest") that guides player movement. Furthermore, game environments do not simply consist of neutral topologies but have a distinct visual aesthetic to make them look enticing. To examine whether such extraneous factors impact player's curiosity for exploration, they are implemented as separate testing conditions. Another potential impact that is part of the evaluation is whether compensation for participation in the study influences exploratory behavior. Compensation is common in academic studies, and researchers of future studies building upon this work may consider offering it to participants. It also represents an incentive for completing the game in a short amount of time, thus increasing the curiosity that design patterns would need to elicit to motivate exploration. In this study

Overall, the study follows a *between-subjects 2x2x2x2 factorial design* with fixed factors: the presence of patterns, goal statement, environment aesthetic, and compensation.

An online experiment was conducted with 254 participants who were randomly sorted into different condition groups. Data collection consisted of questionnaires (both in- and post-game) and game metrics (e.g., distances from path and destination over time, play duration, player position and camera rotation, and instances of going out of bounds, i.e., jumping into a chasm). In addition to direct measures, interpreted emotion ratings were gathered through self-reported emotion words gathered during gameplay. These words were matched to affective components (valence, arousal, and dominance) based on the Glasgow Norms corpus (Scott et al. 2019).

The study results provide evidence for H1 and H2, but not for H3. Section 7.4 discusses the interpretation of results. The contributions of this study lie in providing an initial empirical study into level design patterns for spatial exploration. Results show that level design patterns impact exploratory behavior and that other factors further influence their effects. An explicit goal severely reduces exploratory behavior until that goal is fulfilled and the game becomes more open-ended. Receiving monetary compensation reduces exploration, but patterns motivate players to explore and perceive the experience more positively than when they play without them.

These findings can inform future game design considerations and should also be considered for the design of further studies in this area (e.g., variables to include, data analysis, and whether or not to offer compensation). Overall, the study aimed to be a nuanced, practical example of the complexity of studying video games experimentally and analytically, and provides a foundation for future work in the study of design patterns, curiosity, and player experience.

The following sections describe the design of the experiment, followed by the procedure and detailed results. The discussion section details the findings and explains how the results were interpreted. Finally, the chapter concludes with limitations and an overall conclusion of the study.

Chapter Publications

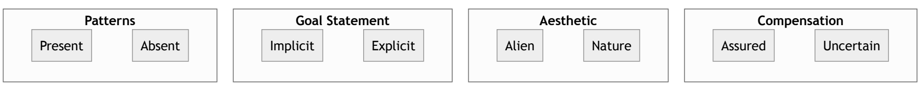
Work presented in this chapter has been published in this peer-reviewed venue:

- **Proceedings of the ACM on Human-Computer Interaction (PACMHCI Journal, Volume 5, Issue CHI Play) – 2021**
  "Level Design Patterns That Invoke Curiosity-Driven Exploration: An Empirical Study Across Multiple Conditions" (M. A. Gómez-Maureira et al. 2021)

7.1 Experiment Design

This section describes the structure and design of the study. Given that it is the second part of a two-part study, it involves aspects that were already discussed in the previous chapter. Especially the research game, *Shinobi Valley* (described in Chapter 6), remains a fundamental component of the experiment design in the second part of the study. While the game will not be described again here, relevant game features are briefly summarized where necessary as a reminder. Design considerations of the game are described with a focus on the role they play for participants, i.e., for the "serious" purpose that the game fulfills as a research artifact rather than its role as a simulated entertainment game.

The experiment for this study is designed to take place online and follows a between-subjects 2x2x2x2 factorial design. It tests the impact of four factors, each of which consists of two conditions. The fixed factors are (1) the presence of patterns, (2) the goal statement, (3) the environment aesthetic, and (3) compensation. Participants are randomly sorted into a condition group and given one of two options in each fixed factor. Participants play "their" randomized version of *Shinobi Valley*, during which data is collected through game metrics and a periodic in-game survey. Afterward, participants answer a post-game survey.



The following sub-sections describe the game variables that are modified between conditions, details regarding randomization of variables, participant sampling, experiment measures, and finally, the experiment setup.

7.1.1 Independent Game Variables

To examine the research questions, the design of *Shinobi Valley* varies in three aspects: the presence of patterns, the presence of a goal statement, and aesthetics. Participants are randomly assigned a combination of these variables. While the controls and general game progression remain unchanged by these variables, the game environment differs depending on which condition (i.e., the combination of variable states) a participant is assigned to. Variables are tested pair-wise, meaning that individual variables always overlap with others. Each participant plays only one possible combination of variables.

The individual game variables are described in the following sub-sections. In addition to game variables, another experiment variable is based on whether participants received financial compensation. This variable is further discussed in section 7.1.3.

7.1.1.1 Level Design Patterns for Spatial Exploration

A crucial goal of the experiment is to investigate whether the implemented design patterns successfully elicit curiosity in participants. To test this, participants take the experiment either with such *patterns present* or with *patterns absent*.

The *patterns present* condition has been the focus of previous design descriptions (see Chapter 6) but is summarized here briefly. Overall, there are 12 *pattern instantiation regions* (PIRs) that include a design pattern to motivate exploratory behavior. These regions are made up of four different kinds of patterns with three implementations each. The regions are distributed across the game environment along a primary path.

In the *pattern absent* condition, the 12 regions of interest are not present in the environment. In some cases, this slightly reduces the amount of explorable space, such as lacking mountains that were designed to be climbable and spatial connections that could be explored. Visual obstructions such as dense forests and the fog zone are removed and replaced with vegetation that mimics the distribution across the rest of the environment. The same is true for out-of-place elements that were meant to attract attention.

It is important to note that the game environment was created and developed with patterns in mind. Initially, the experiment only provided information on which design patterns are most successful in invoking exploratory behavior. The absence of patterns was implemented after they had already been implemented. While care has been taken to ensure that both conditions appear complete and consistent, participants will naturally find more opportunities for exploration in the presence of such patterns. At the same time, participants playing the game in the absence of patterns condition might still exhibit exploratory behavior. This is because the absence of patterns means the *absence of intentionally designed patterns* for this experiment.

Both conditions include areas that may very well attract the attention of participants but are not considered regions of interest, even if they otherwise exhibit traits of some design patterns. Especially *Extreme Points* patterns arise almost automatically depending on the surrounding environment. What differs is the extent and the intentionality of such patterns.

7.1.1.2 Goal Statement

In the experiment, participants need to follow an S-shaped path in the environment to its end to progress and complete the game session. The goal statement condition pair separates participants into playing a version in which they are given this task *explicitly* and a version in which the goal is only *implicitly* evident due to the existence of a path.

In the *explicit goal statement* condition, participants start their game session with two subsequent text messages before they gain control of the player character. The messages state the following (numbers indicate separate message boxes in sequence):

> (1) "This is you! You are a monkey ninja on a journey to meet your master."
> (2) "Your master awaits your arrival at the end of this path."

After the messages have been confirmed, participants are shown a sequence of three slow camera pans from predefined points along the path (figure 7.1). Each of the three pans lasts five seconds and fades over black to the next pan. The sequence of camera pans indicates how to get to the end. The last camera pan shows the ninja master characters sitting on a large stone in the distance, giving participants a visual preview of their destination. In addition to showing the path, the camera pans also present glimpses of the regions of interest meant to elicit curiosity for exploring the surrounding environment. The path preview thus acts as a goal statement for participants and a visual stimulus for what could be encountered if they leave the path.

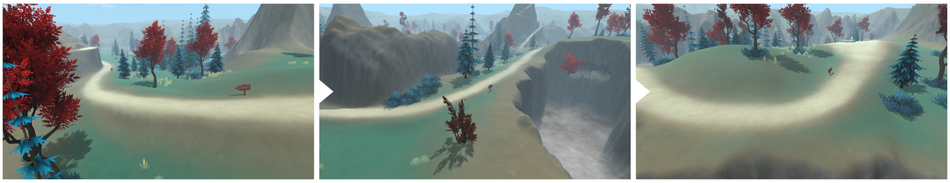


Figure 7.1: Camera shot sequence at the beginning of the game, following the primary path. The signposts shown in the sequence are only present in the explicit goal condition.

After the third camera pan, the camera shows the player character again, and the game proceeds to explain the control scheme to participants. After completing the tutorial, participants receive the following message before starting the game:

> "Now go! Your master awaits."

Already during the path preview, participants can see a series of wooden signs next to the primary path. The signs point towards the location of the master and, thus, to the apparent target destination. In addition to reminding players of the goal statement, the signs provide navigation support, so they do not get lost.

Overall, the *explicit goal statement* consists of three messages, a visual preview of the primary path lasting 15 seconds, and nine wooden signs pointing to the path destination. Consequently, these elements are absent in the *implicit goal* condition.

In the *implicit goal* condition, participants start directly with the game tutorial and receive the following message before starting the game:

> "You can now control your character."

During the game, participants need to orient themselves using the surrounding environment. At the same time, the primary path remains a distinctive visual (and topological) feature. *As such, neither condition is entirely free from any goal statement.* The *implicit goal* condition still presents participants with a goal, but one that is more uncertain and open to interpretation.

7.1.1.3 Visual Aesthetic

To draw valuable conclusions from the experiment, the expressed behavior of participants should be due to the impact of PIRs in the environment. The design of such regions is based on design patterns that are, for the most part, independent of how a game looks. At the same time, creating a game environment that is entirely neutral in its aesthetic appearance is not possible. For this reason, participants play *Shinobi Valley* in one of two visual aesthetics: the *nature aesthetic* condition and the *alien aesthetic* condition. The aesthetic aspects of each are further described in 6.

This control condition pair is not expected to impact exploration behavior. None of the game parameters and mechanics are affected by the game's visual aesthetic. The placement of vegetation is identical for both conditions, and care was taken to keep the dimensions of individual bushes and trees as close as possible.

7.1.2 Game Randomization

Each participant in the experiment plays one possible game version, consisting of a combination of the independent variables described in the previous sub-sections. Whenever a participant begins the experiment, they are assigned a combination of the three game variables (i.e., patterns, goal, aesthetic). Each variable has two possible options. The goal statement and aesthetic variables have a 50% chance for either option.

The pattern variable has a *70% chance of playing with level design patterns present* versus a 30% chance of playing in the absence of patterns. Although this creates an imbalance in the sample sizes between the different conditions, it allows for collecting more data on participants interacting with the (individual) level design patterns and subsequent analysis of those interactions. Considering that the analysis of individual patterns is a fundamental goal in this study, this was considered an acceptable trade-off to maximize available resources (i.e., time and budget for financial compensation). Implications of this decision are discussed as part of the study limitations in section 7.5.

Apart from the independent game variables, participants are randomly assigned one of two possible play directions. Randomizing the starting position in this manner is meant to counteract the impact of uneven distributions of individual PIRs and the potential order effects in encountering them. Since the play direction is not hypothesized to impact the overall efficacy of patterns, play direction is included as a nuisance variable rather than a fixed experiment factor.

In summary, the following game parameters are randomized for each participant:

- Pattern present (70% chance) or absent (30%)
- Goal statement implicit (50%) or explicit (50%)
- Nature aesthetic (50%) or alien aesthetic (50%)
- A→B (50%) or B→A (50%) play direction (treated as nuisance variable)

7.1.3 Sampling

Participants in the study were recruited through a combination of snowball sampling and crowd-sourcing. Snowball sampling included reaching participants through social media, the University environment, and word-of-mouth. Crowd-sourcing took place on three recruitment platforms: *Mechanical Turk* (Amazon 2021), *Prolific* (Prolific 2021), and *SurveyCircle* (SurveyCircle 2021). *Mechanical Turk* (*MTurk*) and *Prolific* participants received *assured monetary compensation* of 3.00 EUR each for completing the study. All other participants could opt into a lottery for *uncertain compensation* of three 20.00 EUR vouchers. The only requirement for participating in the study was that participants have basic English comprehension and that their computer can run the game smoothly. As described in section 7.2, the experiment logs game performance and terminates if it falls below a minimum threshold. From *Prolific*, only female participants could participate; a decision made to counter-balance a lean towards male participants up to that point in the data collection.

Players are hypothesized to be intrinsically motivated to engage with games due to the experiences that they offer (e.g., enjoyment from overcoming challenges, interacting with the game world, social interaction; see R. M. Ryan, Rigby, and Przybylski (2006)). However, it is possible that playing a game for research purposes influences how players engage with it, especially when they are compensated for their time. While some participants may be inclined to finish as fast as possible to maximize their gains, others might feel obligated to do well and earn their reward. In this study, the involvement of an extrinsic reward may affect intrinsic motivation and, possibly, the behavior that is being studied (Eisenberger, Pierce, and Cameron 1999). Given that the effect of an extrinsic reward has not yet been empirically tested for how it influences exploration in video games, *whether players did or did not receive assured monetary compensation is included as a fourth independent experiment variable.*

7.1.4 Measures

The *Shinobi Valley* game experiment primarily collects quantitative measures that are expressions of player behavior and assessments of their personality concerning curiosity. Qualitative measures are taken in the form of free text input. While quantitative measures can appear to deliver precise results, it is important to keep in mind that they are proxy measures for what the *Shinobi Valley* experiment seeks to investigate: curiosity as an emotional impact of design interventions. Quantitative data in the experiment should be understood as sources for constructing arguments for when and why design elements in the game impact participants. Qualitative data is used similarly; as supporting material for formulating arguments. Where it differs is in what material it sources. While quantitative data describes the expressed behavior of participants, qualitative measures are taken to construct an understanding of the motivational and emotional aspects that accompany that behavior.

The following subsections describe the individual measures that are taken in the study.

7.1.4.1 Game Metrics

The game logs player parameters at a repeated interval several times per second. Each log line includes position, camera rotation, avatar movement velocity, the closest distance to the primary path, and distances to start and destination points. Apart from repeated logs, the jumping and running of the player character are logged at the time of input as timestamped events. Timestamps are also logged for arrival and leaving of PIRs, arrival and leaving of start and destination areas, instances of resetting the player character (e.g., jumping into the chasm or when getting stuck in the level geometry for longer than 2 seconds), as well as triggering and completion of the in-game survey.

Additional metrics are generated from the aforementioned measures, primarily through spatio-temporal data created by participants in combination with the predefined locations of PIRs. These include measures for PIR visit counts, PIR stay duration, and spatial entropy of player movement; specifically, Altieri's entropy (Altieri, Cocchi, and Roli 2019), which captures the impact of localized clustering in addition to the overall heterogeneity of spatial data.

The following game metrics are captured at a regular interval of 5 measures per second (5 Hz; i.e., every 200ms):

- **Position of the player character (and position delta)**
  Measured in X, Y, Z position coordinates from the center of the environment (i.e., the virtual world origin point), and as position delta since the last position log. Positions are measured with an accuracy of three digits after the decimal point, with each unit being the rough virtual equivalent of a meter. The position accuracy is thus tracked at the equivalent of 1 mm in the real world. For comparison, the playable area in the game measures 256 x 256 in-game units (equivalent to meters), and the player character can run at a speed of 4 units per second.

- **Distance from the primary path**
  The path distance is tracked using the same measurement unit and accuracy as the player character's position, but with respect to the shortest distance to the primary path. This measure is based on a simplified bezier curve that roughly follows the middle of the visual representation of the primary path in the environment. The path distance expresses the shortest distance between the player character and the primary path. Given that the path's visual representation varies, a path distance of 1 unit (i.e., meter) may be just about off the path in some areas while still on the path in others.

- **Camera rotation (and rotation delta)**
  Measured in quaternions, delta rotations in degrees (pitch and yaw), and absolute delta in degrees. Both delta measures indicate the rotation since the last log entry. In contrast to the movement speed of the player character, the maximum possible delta rotation can differ between participants. This is because the camera rotation directly corresponds to mouse tracking sensitivity and the sensitivity setting that participants choose at the beginning of the experiment.

- **Player character state**
  Two player character states are tracked as binary (i.e., "true" or "false") parameters: whether the player character is currently jumping (i.e., airborne and in an

upwards trajectory) and whether the player character is currently running (as opposed to moving at regular walking speed).

Additional game metrics are captured when specific events occur. In contrast to metrics tracked at an interval, *event-based metrics* are timestamped at the moment of the event itself and are independent of a fixed measure frequency. The following game metrics are event-based:

- **Location triggers**
  Several areas in the game environment have triggers that log when the player character enters or leaves the area. Triggers are implemented as invisible spheres around a given point, with the sphere size corresponding to the size of the area of interest. All regions of interest have such location triggers, as do the starting and destination areas (i.e., the ninja master that awaits participants at the end of the primary path).
- **Out of bounds**
  When the player character jumps into the chasm, their position is reset with accompanying effects indicating that they left the playable environment. In addition to the time this event occurred, the player position is also logged.
- **Player stuck reset**
  As with many games that simulate real-life physics, participants may find themselves stuck in the virtual geometry. The game keeps track of whether participants can move their character and resets their position to a nearby flat terrain after a few seconds if the player character gets stuck. Such occasions are logged with a timestamp and the player character's location at that time. It should be noted that this metric is primarily used to identify potential outliers in the recorded participant data.
- **Movement modifier inputs**
  Participants can use either their keyboards or mouse to make the player character jump or sprint. These events are logged when the respective input is entered.

By capturing these game metrics, the participant behavior in the game can be largely reconstructed for any given point in the experiment. This is particularly helpful when testing the experiment procedure to determine if there are problems in the game code or in how data is logged. For the actual data evaluation, however, most game metrics are used to derive measures that illustrate the play session as a whole. The following measures are derived from game metrics:

- **Durations**
  By using the timestamps of location triggers, stay durations that provide information about the participant behavior can be derived. Stay durations are logged to track how much time was spent, in sum, at a given region of interest. The duration of the entire game session is also tracked, as well as time spent before and after reaching the master.

- **Aggregate counts**
  The overall amount of "out of bounds" and "player stuck reset" events are summed up and tracked for each participant.

- **Session statistics**
  Some game metrics that are tracked at a regular interval are also expressed as session statistics to allow for comparison with measures from other participants. In each case, statistics are created for the entire session, as well as for the timespan before and after players have reached the master. The jumping and running of the player character are tracked in percentage over the session length. Since jumping is a relatively brief event, the percentages are generally low but enable direct comparison between participants with varying play durations. The following statistics are derived for position delta and path distance: mean value, standard deviation, median, and median absolute deviation. For rotation deltas, the same statistics are calculated but without median and median absolute deviation, as camera rotation often happens in short bursts, with the median resulting in zero in many cases.

7.1.4.2 In-Game Player Feedback

During the experiment, a feedback screen pops up at predetermined times to ask participants about their emotional state and to rate their curiosity on a unitless sliding scale. The pop-up screen is broken up into two sub-screens, with each screen focusing on a single question (figure 7.2). The separation into two individual sub-screens is meant to reduce bias when answering the second question. The first sub-screen presents participants with a question requiring them to enter text to progress. The question states:

> "In a word, what is your current emotional state?"

Once participants have entered some text, they can click a button to continue to the second sub-screen, where they are asked to rate their curiosity on a scale from "not curious at all" to "very curious". A slider can be placed and dragged on that scale. The slider position results in a measure of `0` for "not curious at all" and `1` for "very curious". The sliding scale does not provide any numerical feedback to participants but internally logs their input at two decimal places (e.g., `0.75` when the slider is three-quarters towards the "very curious" end of the scale). The slider does not snap to predefined increments, a decision that prevents participants from comparing their current measure to previous feedback. The sliding scale lets participants deliberately capture curiosity and acts as a momentary snapshot of their emotional state. Before participants click on the sliding scale, the slider handle is not visible and thus does not indicate a default neutral point. This increases the likelihood that ratings around the midpoint are set deliberately by participants and not the result of unreflected convenience.

Figure 7.2: The two sub-screens of the in-game player feedback interface.

Once participants leave the starting area in *Shinobi Valley*, an internal timer starts and determines when to present the in-game feedback screen to them. The timer only progresses when no user interface is shown on the screen (such as the feedback or help screen). The timer interval is set to the sequence: `1`, `3`, `5`, `8`, `12`, `17`, `23`, `30`, `38`, `47`, and `57`. This means that the first feedback screen is triggered after one minute, then two minutes later (minute `3`), then again two minutes later (minute `5`), and finally, with a linear increase of 1 additional minute between subsequent intervals. Participants are not expected to play for such a long time, but if they do, their feedback will be requested for up to one hour of playing time. Naturally, the amount of collected feedback is thus dependent on how long participants play. In the pilot study of *Shinobi Valley* the average play time was around 12 minutes. This is also why there are two intervals of 2 minutes between triggering the feedback screen rather than just one, as it provides more feedback at a time when most participants are likely to see it.

It should be noted that the player character needs to be on the ground for the feedback screen to trigger. If the character is “airborne”, the feedback screen is delayed until the character is on the ground again. This decreases the likelihood of the feedback screen appearing in the middle of a jump. The delay is at most 1-2 seconds, such as when players jump from a mountain which causes the longest time spent “ungrounded”. The reason for implementing such a delay is that taking the control away from participants during a game is already a distracting event that can impact their affective state negatively, at least momentarily. The impact would likely be more substantial if the screen were triggered in the middle of an action.

7.1.4.3 General Player Data

After playing *Shinobi Valley*, participants take an online post-play survey that involves questions about themselves, their experience with video games in general, and their experience with *Shinobi Valley*. The survey is similar to the one used in the pilot study, with some minor adjustments.

Demographic questions include age and gender identity, both of which are not mandatory. For gender identity, participants can provide their preferred identity as free text.

Participants are asked to self-identify as one of four types of video game player: “Novice”, “Casual”, “Core”, or “Expert”. These terms are not further explained and are chosen to reflect common terminology among game-playing audiences. As an example, the notion of a “core player” is likely not a familiar term to participants that are not very familiar with video game culture. This makes it more likely for them to self-classify as either “casual” or “novice” players, terms that are less domain specific.

Another question asks participants to estimate how often they have played video games in the last year. A note informs participants that they should include games played on mobile devices but exclude non-digital games such as board games or physical card games.

Possible options are:

- Never
- Less than 1 hour combined over the entire year
- 1 hour over the entire year on average
- 1 hour per month on average
- 1 hour per week on average
- 1 hour per day on average
- More than 1 hour per day on average

Participants are further asked about what game they are reminded of after playing *Shinobi Valley*, as well as what their favorite video game is. Both questions do not need to be answered but provide complementary information regarding a participant's perspective toward video games and the experiment. The next question inquires whether participants chose to leave the primary path and enter free text about why they did or did not. This is followed by a question about whether any game elements stood out to them, both negatively or positively. A subsequent comment field allows participants to comment freely on the game or the experiment.

The questions mentioned above are shown directly to participants and require their input. However, the online questionnaire also captures additional information about each participant. Based on the IP address, geolocation is logged that can be translated into a city and country belonging to that location. A URL parameter that is part of the experiment link is used for logging how participants were sampled and allows for later comparison between participants that were invited via crowdsourcing platforms and those that were reached via snowball sampling. Finally, the time it took participants to complete the questionnaire is measured at three points to estimate whether responses have been taken in a reflected manner. This allows for filtering out participants that responded much faster than the majority as outliers.

7.1.4.4 GUESS Questionnaire

The Game User Experience Satisfaction Scale (GUESS) is a validated scale for various factors contributing to video game experience. It is already used as part of the pilot study and described in more detail in Chapter 6.

In contrast to the pilot study, the GUESS questionnaire in this part of the study does not feature the sub-scales *Usability / Playability*, *Audio Aesthetics*, and *Visual Aesthetics*. The sub-scales of *Narratives* and *Social Connectivity* were already excluded before and are also not part of this experiment. The rationale for involving fewer sub-scales is that the game is no longer being assessed regarding its ability to simulate an entertainment game. By involving fewer questionnaire items, the overall duration of the experiment could be reduced.

Overall, participants rate a total of 26 statements, providing results in four sub-scales: *Play Engrossment*, *Enjoyment*, *Creative Freedom*, and *Personal Gratification*.

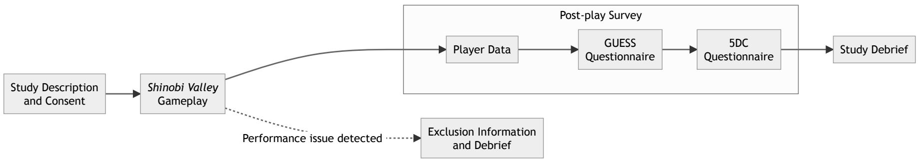
7.1.4.5 5DC Questionnaire

The *Shinobi Valley* experiment is designed to elicit the desire to explore through localized design interventions. Whether or not participants develop such a desire is, in part, influenced by their disposition to become curious. To assess this disposition, the post-play survey includes the Five-Dimensional Curiosity Scale (5DC), which describes an individual's general tendency to become curious (Kashdan et al. 2018). The scale and the questionnaire are further described in Chapter 4.

Within the post-play survey, items of the 5DC are presented to participants in sets of five items per page. The order in which the items are presented is randomized for each participant.

7.2 Procedure

In the study, *Shinobi Valley* is used as an online game and can be played in most modern browsers that support WebGL 2. All experiment steps are online and presented to participants through an experiment website that guides them along the way. The experiment was approved by the *Ethics Review Committee of the Faculty of Science* at *Leiden University*.



The first step is a description of the experiment and a request for consent for logging player data. Participants are not explicitly told that curiosity or exploration is the main focus of the research. Instead, they are informed that they will play a video game for research and how long the study will take ("around 15-20 minutes").

Before continuing to the game, the experiment website checks whether the browser window is large enough for the game to be played in full resolution. If the window is smaller than the game's dimensions (1920 by 1080 pixels), the participant cannot proceed and instead sees a message to play the game on a larger display or resize their window. If the resolution is sufficient, the participant can proceed to the game.

Within the game phase, participants are informed that *Shinobi Valley* should be played with headphones. Participants then proceed with playing the game, starting with the tutorial. The individual game phases are further described in Chapter 6. Participants are randomly sorted into a condition group and assigned a starting position in the game.

During play, the game periodically checks the frame rate at which it runs. When it registers that game has been running at less than 15 frames per second over a more extended period, the game stops and informs the participant that a performance issue has been detected. This check aims to ensure that participants experience the game at a minimum viable frame rate, given that subpar game performance can impact measured player behavior. Although participants are informed as part of the study description that a performant computer is required, it can be erratic to rely on participants to judge whether their computer performs sufficiently well.

While participants play the game, their actions are logged and submitted to a central experiment server. Periodically, an in-game survey appears as an in-game window that cannot be dismissed until it has been filled out.

Participants finish the game by finding the ninja master and waiting for the end of their meditation session. Upon completing the game, the experiment website automatically directs them to the post-play survey.

7.3 Results

The statistical tests conducted in this study use a Bayesian approach (O'Hagan 2008) and are calculated using *JASP* (JASP Team 2020; Marsman and Wagenmakers 2017). The reported *Bayes Factor* (BF_{10}) indicates the probability of the presence of an effect versus the absence (Schönbrodt and Wagenmakers 2018). A BF value over 1 indicates that the tested hypothesis is more likely than the null hypothesis. A value of 1 means that there is an equal chance of the hypothesis being different from the null hypothesis as there is of them being similar. A value below 1 indicates that the null hypothesis is more likely. Unlike classical hypothesis testing, a Bayesian test can indicate the likeliness of the null hypothesis rather than only rejecting it (O'Hagan 2008).

This thesis uses BF synonymously with BF_{10}. However, indexes are provided when not testing against the null hypothesis. Following standard practices (Jeffreys 1961), the study considers ***BF>3*** as *moderate evidence for* a hypothesized effect (i.e., at least three times higher likelihood of a hypothesized effect versus no effect). A result of ***BF<0.33*** indicates moderate evidence *against* the hypothesized effect (effectively, at least three times higher likelihood against a hypothesized effect). These values roughly correspond to a significance level of ***p<0.05*** being interpreted as a statistically significant measure.

In this study, a *two-sided Bayesian T-test* is used to determine whether observations are significantly different. A *two-sided Bayesian Pearson correlation* is used to assess significant relationships between measures. Given the absence of well-informed (and sourced) prior beliefs, the default values for uninformed priors provided by *JASP* are used (Cauchy prior with of ***0.707***). Data for statistical tests is prepared using the *Pandas* package in Python (Reback et al. 2021).

A report of statistical tests and the underlying data can be found in the Open Science Framework (OSF) repository of this study[1], including settings that were used to calcu-

[1]OSF repository: https://doi.org/10.17605/OSF.IO/MVR37

late the results. The following sections describe noteworthy results derived from the experiment data. First, the participant sample and general observations are described. This is followed by results relevant to the experiment factors and the recorded nuisance variables. Finally, results relating to the performance of the four Pattern Instantiation Region (PIR) sets (extreme points, visual obstructions, out-of-place elements, and spatial connections) and their interrelation with experiment factors are presented.

7.3.1 Descriptive Statistics and General Observations

Overall, 389 participants took part in the experiment, out of which 266 completed the game and the post-game survey. Incomplete measures, and participants accounting for the fastest 2.5% of survey completions compared to the median, were excluded. Of the remaining $n=254$ participants, 48% identified as female ($n=122$), 50.8% as male ($n=129$), and 1.2% ($n=3$) identified as non-binary. The mean age was 31.8 ($SD=10.8$, $range=[18, 69]$). 35% of participants were recruited via *MTurk* ($n=89$), 31.1% through snowball sampling and social media ($n=79$), 28.7% from *Prolific* ($n=73$), and 5.1% from *SurveyCircle* ($n=13$). Female participants recruited via *Prolific* balanced out otherwise male-dominant demographics (without *Prolific*, 69.6% of participants were male).

To recall, the study uses a between-subjects 2x2x2x2 factorial design, with play direction and gender recorded as nuisance variables. Each participant contributes data to each factor and is randomly assigned one of the two conditions (with 50% probability for all experiment factors and play direction but 70% probability for playing with patterns versus 30% without).

The participant breakdowns for the individual experiment factors are:

- Played with patterns 72.4% ($n=184$; vs. $n=70$ without patterns)
- Played with goal statement 51.2% ($n=130$; vs. $n=124$ without)
- Played in alien environment 48.8% ($n=124$; vs. $n=130$ in nature environment)
- Played with assured financial compensation 63.8% ($n=162$; vs. $n=93$ without).
- Played in A→B direction 50.8% ($n=129$; vs. $n=125$ in B→A direction)

The participant breakdown closely matches the randomization percentages set as part of the experiment design. Participant procurement for the non-compensation group fell slightly short of the even-split target.

Table 7.1: 'Glasgow ratings' based on translated emotion words, split out over the three emotion dimensions arousal, dominance, and valence. For each, individual means and standard deviations are listed, which in turn provide means and standard deviations across all participants. Data points are split out to ratings 'before' and 'while' waiting.

	Arousal				Dominance				Valence			
	Indiv. Means		Indiv. SDs		Indiv. Means		Indiv. SDs		Indiv. Means		Indiv. SDs	
	M_M	SD_M	M_{SD}	SD_{SD}	M_M	SD_M	M_{SD}	SD_{SD}	M_M	SD_M	M_{SD}	SD_{SD}
Before Waiting	5.18	1.48	0.23	0.51	5.62	1.10	0.20	0.44	6.30	1.80	0.33	0.72
While Waiting	4.41	1.31	0.71	0.68	4.90	1.02	0.50	0.56	4.70	1.88	0.75	0.90

The average frequency of playing games when converted to was ***Mn=5.5*** (***SD=1.5***), corresponding to an in-between of "1 hour per week on average" and "1 hour per day on average" . The average gamer type self-identified as between "casual" and "core" (***Mn=2.6***, ***SD=0.9***).

The average play time was ***Mn=10.3*** minutes (***SD=3.6***, ***range=[6.6, 30.4]***). The mean play time before waiting was ***Mn=3.7*** minutes (***SD=3.7***, ***range=[0.6, 27.7]***), vs. ***Mn=6.5*** while waiting (***SD=1.4***, ***range=[2.7, 12.4]***).

Results of overall GUESS ratings (assessed on a scale of 1 for 'worst' to 7 for 'best') were:

- Creative Freedom: ***Mn=4.2*** (***SD=1.2***) — compare to ***Mn=5.15*** in pilot
- Play Engrossment: ***Mn=3.9*** (***SD=1.3***) — vs. ***Mn=4.78*** in pilot
- Enjoyment: ***Mn=3.7*** (***SD=1.6***) — vs. ***Mn=5.18*** in pilot
- Personal Gratification: ***Mn=4.3*** (***SD=1.3***) — vs. ***Mn=5.05*** in pilot

All GUESS ratings are close to the scale's midpoint but generally lower than the game's ratings during the pilot study.

The average in-game curiosity rating was ***Mn=0.6*** (***SD=0.2***, ***range=[0.01, 1.0]***); slightly above the scale mid-point of ***0.5***. Ratings steadily decreased over the play session, with ***Mn=0.71*** (***SD=0.2***) for the first rating, going down to ***Mn=0.49*** (***SD=0.3***; at ***n=34*** due to different play lengths) for the fifth rating moment.

Players used ***n=104*** unique emotion words to rate their emotional state when providing curiosity ratings. Before waiting, the most frequent responses were "curious" (***12.6%***), "calm" (`8%`), and "happy" (`8%`). While waiting, the most frequent responses were "bored" (`24.4%`), "annoyed" (`7.5%`), and "curious" (`6.4%`). Translation of the words to emotion dimensions via the Glasgow Norms resulted in means and SDs for each dimension (i.e., arousal, dominance, and valence) for each participant. SDs indicate the "emotional range" of words provided by the participant throughout the play session. From the individual participant results, means and SDs of each emotion dimension can be calculated across participants as well, resulting in a "mean of individual means", "SD of individual means", "mean of individual SDs", and "SD of individual SDs".

The resulting "In-ame *Glasgow* Ratings" are listed in table 7.1. A *paired-sample Bayesian T-Test* of *Glasgow* ratings before and after waiting shows *decisive evidence* for measures differing between the two experiment phases (`BF>1k`; i.e., `1000` times more likely than no difference). Individual means are higher before waiting for all emotion dimensions, while individual SDs are lower before waiting.

Most measures of player behavior differ notably before waiting, compared to while waiting; such as play duration (shorter before waiting; `BF>1k`), movement speed (`BF>1k`), and camera motion (`BF>100`), and spatial entropy (`BF>1k`).

Results of qualitative data, gathered in the form of coding participant comments, are shown in table 7.2.

7.3.2 Fixed Factor Results

In order to examine the impact of fixed factors on player behavior and emotional experience, a *Bayesian ANOVA test* was carried out for several dependent variables. These include game metrics (i.e., distance traveled from the path, distance traveled from the destination, play duration, position, rotation, and instances of going out of bounds, i.e., jumping into the chasm) and the *Glasgow* emotion ratings. Such a test results in a list of models (comprised of different combinations of the fixed factors) that have a likelihood of explaining differences in a specific measure (expressed as $\mathrm{BF_M}$). For each fixed factor (and possible combination of fixed factors), a likelihood is calculated that they are part of a model that explains the difference (expressed as $\mathrm{BF_{incl}}$). Finally, post hoc T-Tests show the likelihood of a fixed factor contributing to differences in a particular measure (expressed as BF_{10}).

Table 7.2: Notable 'tagged' comments with total counts, as well as split by 'with' or 'without' pattern and goal condition. Rows in the upper section are coded from reasons given for leaving the path, rows in the middle section are coded from elements that stood out to participants, and rows in the bottom section are valence of comments left for impression of the game as a whole. The table only contains comments that were given by at least 10 participants in total, and that are relevant to the posed hypotheses. Rows are sorted by overall count within each section.

			Pattern split		Goal split	
Tag	Meaning	counts	with	w/o	with	w/o
explore	explore in general	142	105	37	67	75
wait	to pass time while waiting	80	51	29	61	19
landmark	explore a landmark (unspecified target)	45	40	5	25	20
boredom	to alleviate boredom	32	21	11	17	15
mountain	to go to specific PIR: mountains	26	25	1	15	11
boundaries	to test limits of environment	26	17	9	13	13
expect	to find an expected game element that is not implemented	23	15	8	11	12
rocks	to go to OOP PIRs	16	16	–	7	9
scenery	to look at aesthetic elements in the environment	10	7	3	6	4
fog	to go to specific PIR: ground fog	10	10	5	3	7
chasm	to go to explore chasm (possibly incl. cliff cave PIR)	10	6	4	7	3
landmark	game area: any landmark	68	63	5	30	38
noInteraction	lack of interactive elements in the game	60	43	17	35	25
scenery	aesthetic elements of the game environment	58	41	17	29	29
wait	negative experience of having to wait	32	19	13	16	16
mountain	game area: mountains	32	30	2	17	15
cave	game area: caves	27	27	–	13	14
relaxing	overall atmosphere is experienced as calming	20	15	5	13	7
fog	game area: fog	19	19	–	9	10
rocks	game area: stone stacks	13	13	–	3	10
noReward	lack of validation for actions by the player	12	11	1	5	7
noGoal	lack of purpose or goal	11	6	5	3	8
val-pos	Valence of comment: positive	57	44	13	31	26
val-neg	Valence of comment: negative	36	22	14	12	24
val-neutral	Valence of comment: neutral	30	23	7	13	17
val-mix	Valence of comment: mixed positive and negative	18	12	6	10	8

Table 7.3: Fixed factor ANOVA results: Best models of Bayesian ANOVA for dependent variables, if model Bayes factor $BF_M > 3$. Results are split out for 'before waiting' and 'while waiting'. Individual fixed factors in the model are sorted in descending order by probability of inclusion in the model (BF_{incl}). Post Hoc T-Test results (BF_{10}) are included as superscripts if at least $BF_{10} > 3$, reported in steps: >3, >10, >100, >1k (1000). Interaction effects (e.g. [Goal × Pat]) do not have an associated BF_{10}. Fixed factor abbreviations are: Pattern (Pat), Compensation (Comp), and Environment (Env).

	Before Waiting		While Waiting	
Dependent Variable	Best Model (in order of incl. probability)	BF_M	Best Model (in order of incl. probability)	BF_M
Spatial Entropy	$Goal^{1k}$ + Pat^{10} + [Goal × Pat]	25	$Comp^{10}$ + $Goal^{10}$ + [Comp × Goal]	33
Path Dist. (M)	$Goal^{1k}$ + Pat^{100} + [Goal × Pat] + $Comp^{10}$	38	Pat^{1k} + [Goal × Comp] + $Comp^{3}$ + Goal	48
Path Dist. (SD)	$Goal^{1k}$ + Pat^{10} + $Comp^{10}$ + [Goal × Pat]	22	[Comp × Goal] + $Comp^{10}$ + Goal	31
Destination Dist. (M)	$Goal^{10}$ + Pat^{3} + [Goal × Pat] + Env	12	$Goal^{100}$ + [Goal × Comp] + $Comp^{3}$	34
Destination Dist. (SD)	*Null*	50	$Goal^{10}$+[Goal × Pat]+$Comp^{3}$+[Goal × Comp]+Pat	12
Duration	$Goal^{1k}$ + Pat^{3} + [Goal × Pat]	38	*Null*	26
Position Delta (M)	Goal	14	$Comp^{100}$ + Goal + [Comp × Goal]	17
Position Delta (SD)	$Goal^{1k}$	13	$Comp^{1k}$ + Pat	32
Rotation Delta (M)	$Goal^{10}$	25	*Null*	18
Rotation Delta (SD)	$Goal^{3}$	39	*Null*	21
Out of Bounds	$Goal^{10}$ + Pat + [Goal × Pat]	19	$Comp^{100}$	33
Glasgow Arousal (M)	*Null*	48	Pat^{3}	25
Glasgow Arousal (SD)	$Goal^{100}$ + Pat	16	$Goal^{3}$	39
Glasgow Dom. (M)	*Null*	24	*Null*	13
Glasgow Dom. (SD)	$Goal^{3}$ + Pat	12	Pat^{10} + $Goal^{10}$	18
Glasgow Valence (M)	*Null*	22	Pat^{3} + $Comp^{3}$	20
Glasgow Valence (SD)	$Goal^{10}$ + Pat + Comp	7	$Goal^{10}$ + Pat^{10}	33

The *Bayesian ANOVA* tests were run across the fixed factors "patterns", "goal", "environment", and "compensation". Two nuisance factors ("gender" and "play direction") were added to the null model and were thus included in all tested models. The exact settings are included in the OSF repository[2].

Table 7.3 shows an overview of the tests, the best model to explain differences in each variable, and the BF_{10} value of each fixed factor where ***BF_{10}>3***.

7.3.3 Differences Between Design Patterns

To compare differences between the design of patterns, measures relating to individual *Pattern Instantiation Regions* (PIRs) are grouped into sets: *Extreme Points* (EXP), *Visual Obstructions* (OBS), *Out-of-place Elements* (OOP), and *Spatial Connections* (SPC).

[2]OSF repository: https://doi.org/10.17605/OSF.IO/MVR37

Each PIR set consists of three instances in the game environment. Results for differences between patterns are based on ***n=184*** (corresponding to 70% of the sample), as participants without patterns do not contribute any relevant data. PIR set measures are based on player activity in a predefined radius around individual PIRs of 8 game engine units (roughly equivalent to 8 meters). For each PIR, three measures are calculated:

- Spatial entropy (dispersion of player movement)
- Visit count (unique entries into a PIR lasting at least 1 second)
- Stay duration

Since only movements within a confined radius are considered for each PIR, spatial entropy only indicates player movement within the PIR radius.

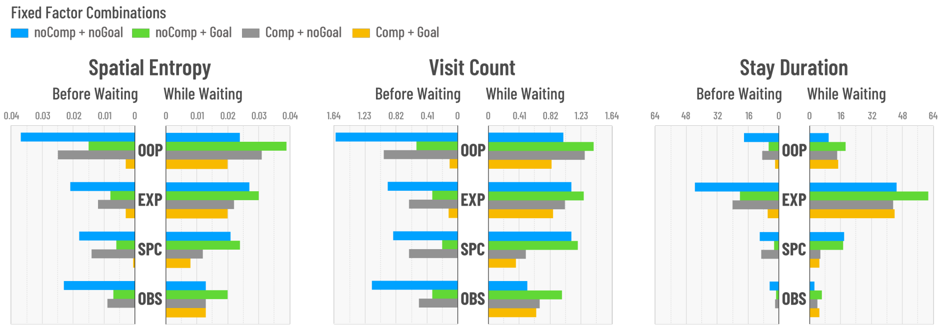


Figure 7.3: Graphs showing mean measures of spatial entropy (left), visit count (middle), and stay duration (right) of the four PIR sets: *Out-of-place Elements* (OOP), *Extreme Points* (EXP), *Spatial Connections* (SPC), and *Visual Obstructions* (OBS). For each of the three graphs, bars extend left to illustrate measures "before waiting" and right for "while waiting". Color coding of the bars indicates the combination of compensation and goal condition for a measure.

Bayesian repeated measures ANOVA tests across PIR sets show decisive evidence (***BF>1k***) for differences in PIR sets beyond the impact of subject factors (goal statement, environment aesthetic, or compensation). Figure 7.3 shows visual graphs of PIR set measures for different fixed factor combinations, as well as for before and while waiting. ANOVA tests show strong evidence that the "environment aesthetic" factor has no effect on these measures and is thus not included in the figure.

Table 7.4: PIR Sets repeated measures ANOVA results: Best models of Bayesian ANOVA for dependent variables, if model Bayes factor $BF_M > 3$. The top half of the table lists results for 'before waiting', the lower half for 'while waiting'. Individual fixed factors in the model are sorted in descending order by probability of inclusion in the model (BF_{incl}, see supplementary material for values). Post Hoc T-Test results (BF_{10}) are included as superscripts if at least $BF_{10} > 3$, reported in steps: $>$3, $>$10, $>$100, $>$1k (1000). Interaction effects (e.g. [Goal × Pat]) do not have an associated BF_{10}. Post Hoc comparison for individual PIR sets are listed in the last column and sorted by means. Fixed factor abbreviations are: Pattern (Pat), Compensation (Comp), and Environment (Env).

Dependent Variable	Best Model (in order of inclusion probability)	BF_M	PIRs in order of means
Before Waiting			
PIR Spatial Entropy	PIRs + Goal^{1k} + Comp^{1k} + [PIRs × Goal]	40	OOP > EXP = OBS = SPC
Stay Duration	PIRs + Goal^{1k} + [PIRs × Goal] + Comp^{10} + [PIRs × Comp]	115	EXP > OOP ≈ SPC > OBS
Visit Counts	Goal^{1k} + PIRs + Comp^{1k}	27	OOP > EXP = OBS = SPC
While Waiting			
PIR Spatial Entropy	PIRs + Comp^{1k}	41	OOP ≈ EXP > OBS = SPC
Stay Duration	PIRs	18	EXP > OOP ≈ SPC > OBS
Visit Counts	PIRs + Comp^{100} + [PIRs × Env] + [PIRs × Comp] + Env	27	OOP = EXP > OBS = SPC

Table 7.4 shows the ANOVA results, with the last column indicating the order of means of individual PIR sets. In some cases, PIR sets are statistically equal (e.g., PIR spatial entropy before waiting: OOP is higher, but EXP, OBS, and SPC can be considered equal), even if differences seem to exist according to the means (as shown in figure 7.3). In such cases, between-subject factors such as goal and compensation are a likely cause, according to the best model. For the aforementioned example, goal, compensation, as well as an interaction effect between PIR sets and goal statement impact the measure. For an interpretation of differences between PIR sets regardless of other factors, "PIRs Post Hoc comparisons" in table 7.4 display the most probable results.

It should be noted that patterns do not perform uniformly. Therefore, the results of PIR sets should be understood as including some performance bias by individual pattern implementations. Table 7.5 lists stay durations and visit counts for individual PIRs of the four PIR sets. *Ground Fog* stands out as having been visited three times more often

Table 7.5: Visit counts and overall stay duration for individual PIRs, sorted by PIR sets and in order of mean visit count across participants. Visits are individual instances of at least > 1 sec time spent in a PIR. Stays are listed in percent of a player's session length.

Design pattern	visited by (n)	Mn_{visit}	SD_{visit}	$Mn_{\%stay}$	$SD_{\%stay}$
(OOP) Stone Stack A	42.9% (79)	1.5	0.8	1.74	1.99
(OOP) Stone Stack B	44.6% (82)	1.4	0.7	1.45	2.03
(OOP) Stone Spiral	45.7% (84)	1.3	0.6	1.76	1.80
(EXP) Mountain B	48.4% (89)	1.3	0.6	7.08	4.10
(EXP) Mountain C	44.0% (81)	1.2	0.5	4.94	4.71
(EXP) Mountain A	31.0% (57)	1.1	0.3	3.81	3.06
(SPC) Cliff Cave	28.8% (53)	1.6	0.8	2.83	2.01
(SPC) Hill Path	29.3% (54)	1.2	0.5	1.14	0.91
(SPC) Mountain Cave	24.5% (45)	1.1	0.3	1.29	1.57
(OBS) Ground Fog	49.5% (91)	1.4	0.6	0.73	0.60
(OBS) Forest B	18.5% (34)	1.2	0.5	0.79	0.90
(OBS) Forest A	19.6% (36)	1.0	0.2	0.65	0.61

than other patterns in OBS. *Mountain A* stands out in EXP for fewer visits and shorter stay durations.

7.3.4 Notable Correlations

Bayesian Pearson correlations were calculated to provide context for measures for which a statistical correlation was not assured (e.g., path distance and spatial entropy are logically correlated). PIR spatial entropy decisively correlates with PIR visits and stay durations (**BF>1k**) and is thus used to assess correlations between PIR sets and other metrics.

7.3.4.1 Before waiting: PIR sets

All PIR sets correlate positively with *Glasgow* SDs of all emotion dimensions (**BF>1k**, highest correlation for OOP) but not with *Glasgow* means. They positively correlate with participants going out-of-bounds (i.e., jumping into the chasm) for OOP, SPC, and OBS (all **BF>1k**, highest correlation for OOP), but not EXP. Camera movements positively correlate with all PIR sets entropies (**BF>1k** for all but SPC, which had **BF>30**); here, the highest correlation was with EXP. PIR sets do not correlate with game frequency or player type.

7.3.4.2 While waiting: PIR sets

Positive correlation with game frequency and player type for EXP (***BF>30***), OBS (***BF>30***), and SPC (***BF>3***); but not OOP. *Glasgow* measures do not correlate, except for EXP and arousal SD (***BF>3***). Positive correlation with out-of-bounds events for OBS (***BF>3***) and EXP (***BF>1k***). Camera movements positively correlate for EXP and SPC (both ***BF>1k***).

7.3.4.3 Non-correlations

Some correlation results are notable for their *lack* of correlation with other measures. 5DC measures showed evidence for a lack of correlation with game metrics, in-game curiosity ratings, or Glasgow ratings. The only exception is the *Thrill Seeking* dimension, which correlated with variation in camera rotation before waiting (***BF>10***). PIR set measures did not correlate with age, GUESS ratings, or in-game curiosity ratings.

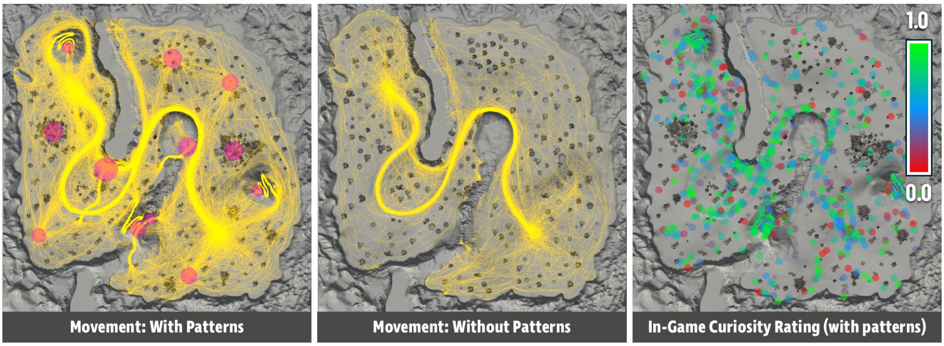


Figure 7.4: Player movement paths for the “with patterns” (left, includes pattern locations) and “without patterns” (middle) experiment factors; and distribution of in-game curiosity ratings (right).

7.3.5 Nuisance Variables

Play direction was recorded as a nuisance variable but evaluated through a *Bayesian Student T-Test* to assess its impact on measures. Most measures did not differ by play direction. Of note are path distance mean (***BF>100***) and SD (***BF>1k***), both especially “while waiting” (***BF≈1k***), and differences in the OOP “while waiting” measures visit count (***BF>1k***), stay duration (***BF>3***), and PIR spatial entropy (***BF>1k***). Here, the proximity of *Stone Stack A* to Zone A likely provided a more potent attractor than an equivalent OOP pattern for players heading toward Zone B.

Participant gender was reduced to female and male participants to assess the impact on measures through a T-Test. Measures impacted by gender differences are likely affected by a difference in "gamer type" (***BF>1k***) and "play frequency" (***BF>3***), with female players having lower measures in both due to differences in sampling distributions. GUESS measures Engrossment, Enjoyment, and Personal Gratification differ (all ***BF>30***, all higher for female participants). In-game curiosity ratings are increased for female players (***BF>100***), as are Glasgow ratings for arousal (***BF>3***) and valence (***BF>3***) while waiting. Female players had shorter (***BF>30***) and fewer (***BF>10***) visits to SPC PIRs while waiting, as well as fewer visits (***BF>3***) to EXP PIRs while waiting. Finally, female players moved slower (***BF>30***) and had fewer camera movements (***BF>100***).

7.4 Discussion

The primary goal of this study is to examine the effect of level design patterns for spatial exploration on player behavior and experience. Across multiple measures, results show that the presence of patterns indeed influenced how players interacted with the environment, and that patterns had an emotional impact. However, how exactly players were influenced depended on other factors. While results suggest that environment aesthetic has little to no impact, having a goal and being compensated evidently affects exploration. In some circumstances, the relative impact indeed exceeds that of pattern presence.

It is crucial to discuss player behavior over two phases of the game: before waiting for the master, and while waiting for the master to stop meditating. It can be hypothesized that a player's motivation for exploration and emotional experience shifted at this point, although how exactly depends on the condition group. As such, the following sections discuss the differences between these two game phases.

Two nuisance variables were assessed in the study: play direction and gender. Play direction impacted player behavior, as players generally seemed to explore more while waiting when they ended in Zone A. Although the map was designed to be reversible, Zone A has an *Out-of-Place* element nearby, whereas Zone B features a *Visual Obstruction* element. Based on the popularity of patterns from this set, *Stone Stack A* likely provided a stronger motivation for exploration, whereas Zone B had fewer interesting PIRs in close range. Aside from a preference for visiting *Stone Stack A*, however, the overall impact appears limited. In addition to play direction, the demographic of players also had some impact. Female players generally had a higher emotional investment in the game and scored their game experience higher (GUESS). Neither of these impacted the results in a way that made them specific to players based on gender.

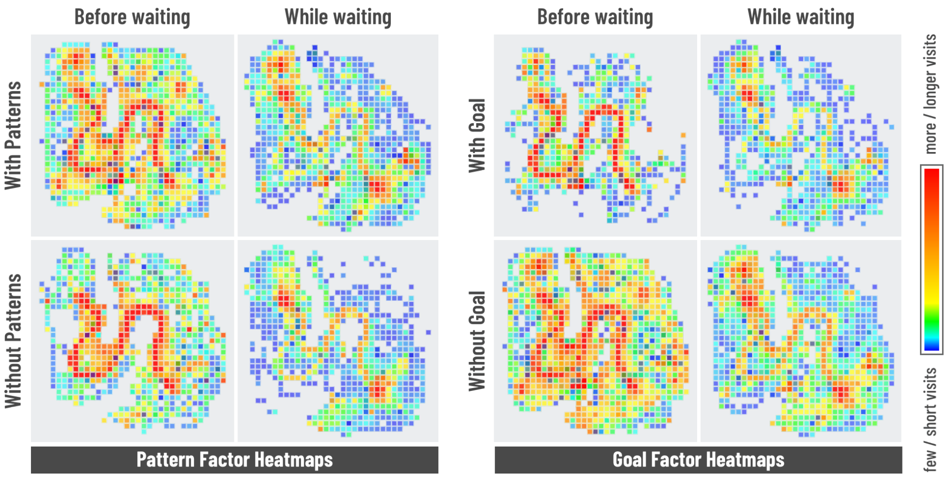


Figure 7.5: Heat maps of player presence split out by the experimental factors of goal statement and pattern presence.

7.4.1 Impact of Patterns

In general, level design patterns caused participants to venture further away from the path and further away from their destination (i.e., the master), resulting in movement across the environment that was overall more dispersed. These differences in exploratory behavior are visible in the visualizations of player presence (see figure 7.4 and figure 7.5) and confirmed by the statistical analysis. Although these results come with certain caveats (discussed in the following sections), patterns affected exploratory behavior. As such, *H1a is supported by the results of the study*. The impact of individual patterns is discussed in more detail later in this section.

In addition to affecting behavior, it was hypothesized that the patterns would also positively affect participants' emotional experiences. This was measured in two ways: through the in-game capture of emotion words and the post-game measures. However, the GUESS showed little to no differences between conditions. This is not necessarily a fault of the GUESS but possibly a side effect of the study design. Due to the decision to make participants wait for five minutes in an attempt to gather data under different circumstances, players likely grew bored. This is supported by *Glasgow* ratings of the in-game reported emotion words, which saw a decrease in valence, dominance, and arousal while waiting compared to before waiting. This suggests that the last five minutes could have colored participants' overall experience, eliminating any differences the GUESS might have uncovered. However, there is a difference in comments that participants made: those who played with patterns were more likely to comment positively about the game overall.

The results also show an impact of patterns on the in-game *Glasgow* ratings derived from emotion words. This effect, however, is primarily visible in the spread (i.e., standard deviation) of the ratings. Before waiting, *Glasgow* means are not affected. On the other hand, the impacts on spread were primarily due to the goal condition and only to a lesser extent due to the presence of patterns. While waiting, patterns had a small impact on *Glasgow* means, which happened in combination with receiving assured compensation. Patterns also impacted the spread of dominance and valence in combination with the goal condition.

Overall, the results suggest that patterns impacted the range of emotions expressed through the in-game ratings, with the emotional range increasing in the presence of patterns. Before waiting, a lack of patterns did not necessarily result in a more subdued emotional experience. Participants that cared to explore did so, while those that did not were driven by finding out what they were supposed to do, rather than being negatively impacted by a lack of patterns. However, the presence of patterns likely led some participants to explore or at least made an emotional impact.

While waiting, the presence of patterns is responsible for higher arousal and valence. This happens in combination with compensation, suggesting that participants that rushed to the stated goal (more likely driven by extrinsic, financial motivation) found elements that interested them while waiting as compared to those playing without patterns. It is unclear, however, whether the impact was due to exploratory curiosity or the desire to alleviate boredom. Participant comments suggest a mix of motivations, e.g., “left path to explore” (55.9%), because of “having to wait” (31.1%), to “explore a landmark” (17.7%), or “due to boredom” (12.6%). The spread of emotional values was increased due to patterns while waiting, suggesting more highs and lows in their play experience.

Having patterns elicited more comments from participants, suggesting that participants with patterns felt more strongly about their experience and the effort they put into the study. Although they more commonly commented on leaving the path to explore, they were also more likely to mention the lack of interaction in the game. It can be hypothesized that the presence of patterns created expectations. The relative novelty of encountering PIRs was likely not perceived as a reward in itself. This is why the emotional impact was more tied to fluctuations rather than an overall increase. Players probably enjoyed the moments when they were engaging in exploration but may have experienced disappointment when their efforts went unrecognized by the game system (either through a reward or by encountering actual interactive content).

Based on these findings, there is sufficient *statistical support for H1b*, albeit with some caveats. The presence of PIRs alone is not sufficient for increasing emotional investment. *Instead, they afford a possibility for exploration that, when realized, increases emotional investment.*

7.4.2 Impact of Goal Statement

Whether or not players were given a goal had a substantial impact on the effects of patterns. Before waiting for the master, among participants without a goal, those with patterns ventured further from the path than those without. They were also further away from the destination point (the master), i.e., they moved around more as they closed the distance to the destination. Entropy measures confirm this observation.

These differences were severely reduced, however, when a goal was introduced. When given a goal, the presence of patterns had a considerably lower impact on any of the measures. Although it was hypothesized that having a goal would reduce exploration, the magnitude of the difference is surprising. The goal formulation is not very specific and relatively subtle; it only informs the player that they are in search of their master and that he awaits them. Additionally, signs along the path point in the master's direction. The path itself, however, is present in all conditions. It can be argued that the path always hints at a goal, as it is reasonable to assume that a path leads to somewhere of interest. Thus it is not unreasonable to suspect they would follow the path as one of their first actions.

Nevertheless, participants not provided with a goal likely spent the first part of the game, at least in part, in search of what to do. Overall, in the presence of patterns, participants without a goal were still more likely to leave the path behind and explore the environment's boundaries than those having no patterns present. A possibility is that PIRs are of interest to participants irrespective of whether or not a goal is provided, but that the difference is masked by participants without a goal figuring out what to do.

While waiting, the data indicates a different behavior. Generally, participants with patterns exhibited more exploratory behavior than those without. Particularly interesting, however, is that participants with a goal explored more than those without. This is perhaps because participants with a goal explored less before finding the master. They were focused on accomplishing their goal when the game started. Once the game provided them with a new goal (i.e., waiting for the master to finish meditating), they felt free to explore. At this point, participants with patterns explored more than those without. Participants that had already explored before because they did not have a goal, did not feel the need to explore as much once they had to wait. Based on these findings, *H2 is considered to be supported by the results.*

When considering emotional impact, players without a goal had higher fluctuations in their emotional experience. However, this is only true before waiting for the master. While waiting, the opposite is true: player affect fluctuated more when an explicit goal was given. Being uncertain about the game's goal likely creates more potential for emotional investment, as players take it upon themselves to find out what the game is about. As the other data suggests as well, participants with a goal were likely more focused on achieving it. Once they are asked to wait, they are presented with a new situation.

Meanwhile, players with no goal were "given" one while waiting. While fluctuations in emotional investment do not necessarily indicate that players enjoy the experience more overall, the concept of designing for interest curves or experiential fluctuations in a game (e.g., Schell 2008) is understood as a strategy to increase overall interest. The results show that having a goal had little impact on the player affect means.

Despite the findings, it is not necessarily the case that a goal reduces exploration in all situations. In part, the results may be due to the nature of the experiment. While players may prioritize a goal or "quest" when playing an entertainment game, it is also not unlikely for them to abandon it in favor of freely exploring an (open) environment when presented with one — likely, this depends on the player and their play style. There is a possibility that, due to participants knowing they were participating in a study, they expected to receive instructions on what they were supposed to accomplish. Those who received a goal prioritized it, thinking it would be necessary to complete it to finish the study successfully. Those who did not receive a goal could have been motivated by finding out what they should do.

As such, it is possible that participants' motivation to explore was not strictly one of curiosity but impacted by seeking a purpose in the context of the study. However, if this were their only motivation, one would expect players to remain on the path, as it gave an implicit indication of where such a purpose might be found. Since this is not the case, it is plausible that patterns still had an impact and that players were not solely motivated by their desire to complete the experiment.

7.4.3 Impact of Compensation

As stated before, it is possible that the addition of an extrinsic reward, i.e., monetary compensation, could influence intrinsically motivated exploration. In addition to players looking for what they were supposed to do to finish the study, the addition of an assured monetary reward could have motivated players to finish the study as quickly as possible. If this were the case, such participants would be expected to put in minimal effort, spending as little time as possible and exploring only to a minimal extent.

Before waiting, whether or not people were compensated had limited effect. Some differences can be seen in how far participants ventured from the path, although patterns and goal statement had a more substantial influence. While waiting, however, compensation was more likely to influence measured behavior. It was the most likely measure for several dependent variables, including spatial entropy, distance from the path, and distance from the destination. Participants were also less likely to see what would happen if they jumped into the chasm. Overall, this shows that participants who were assured compensation were less likely to leave their destination once they had to wait, suggesting they wanted to get to the end as quickly as possible.

Regarding emotional experience, compensation had little influence. However, it was the most significant contributor to differences in valence means while waiting. Interestingly, valence was higher on average for participants who were assured compensation (note that this is the only measure that was significantly higher among people who were being compensated). This suggests that participants who were assured compensation were more content knowing they would progress the experiment within a particular time. Likely, those who were not assured compensation (especially those without a goal who had already spent more time exploring) were more annoyed at "being made" to wait. The presence of patterns, in turn, mitigated this somewhat.

7.4.4 Analysis of Patterns

Besides examining the overall impacts of patterns, the study aims to investigate the impacts of the individual patterns themselves. To this end, only the data from participants with patterns in their game environment was analyzed in detail. This was also the rationale for randomizing with a 70% chance of having patterns.

Before waiting, participants without a goal or compensation interacted with patterns the most; they tended to visit PIRs and stayed for a while. On the other hand, participants who had both a goal and were being compensated barely visited any PIRs and did not stay long at those they visited. This suggests that they were trying to get to the master as quickly as possible. Participants without a goal and with compensation visited more PIRs and stayed longer than those with a goal and without compensation. It appears that participants without a goal searched for one, while the compensation drove them forward. Those who were not being compensated took more time to explore the PIRs, even if they had a goal statement.

While waiting, participants are more active in exploring design patterns. Overall, participants visited more PIRs and stayed longer while waiting. Since they knew they had time to spend at this point, they took more time to look around. Participants with a goal who were not compensated visited the most PIRs and stayed the longest. This is in line with previously discussed findings that those with a goal spent less time getting to the master and then used the waiting time to explore. Similarly, exploration of patterns remained lowest among participants with a goal who were compensated — although they were also likely to get to the master early, they were less willing to venture farther away again to explore patterns in the environment.

7.4.4.1 Out of Place (OOP)

PIRs of this pattern attracted the most visitors and with relatively short visits. Spatial entropy, however, was generally high. This suggests that the pattern causes local exploration, where an object of interest is examined from multiple angles. The reason could be to examine the visual qualities of the object itself or to find out what function it could serve. In many games, OOP elements guide players to rewards (e.g., collectibles and upgrades for the player character), interaction opportunities, or game narrative progress. In such cases, finding out what can be done at these elements is a game mechanic in itself (e.g., requiring players to perform specific actions to make progress). Continued engagement in these regions could indicate the desire to gather more clues about these elements. Furthermore, all patterns except OOP were more attractive to players with higher game experience. This could suggest that PIRs of this pattern have universal appeal, regardless of gaming experience, while others attract only more experienced players.

7.4.4.2 Extreme Points (EXP)

EXP PIRs were visited by many players and caused them to stay longer than other patterns. One reason for this could be that players use the higher vantage points to get a lay of the land. It allows players to visually explore the environment, i.e., gain an understanding of it without having to travel there. This is perhaps especially the case for players without a goal, who stayed the longest at EXP PIRs, and before waiting. While waiting, stay durations are relatively similar regardless of fixed factors. It could be that reaching these patterns is challenging, and, as a result, succeeding in that challenge can feel rewarding in itself, causing players to take a moment to appreciate the result of their effort. The EXP pattern correlating with the spread of arousal ratings suggests that interaction with the pattern has moments of varying excitement. Reaching a high place also allows players to see their surroundings from a new and interesting perspective. As such, participants may stay there for aesthetic reasons (i.e., to enjoy the view), as is indicated by a correlation with increased camera rotation. Even if the game does not provide any specific interactivity, surveying the environment from a vantage point can be experienced as an engaging activity. Out of all patterns, EXP PIRs were most often mentioned by participants as reasons to leave the path or as noteworthy features.

7.4.4.3 Spatial Connections (SPC)

PIRs in this pattern were not visited as often as EXP or OOP patterns, and participants stayed for short periods. However, they stayed longer at SPC PIRs than at OBS PIRs. The *Cliff Cave* had the most prolonged stay duration. Compared to the others, it offered a unique vantage point of the environment (i.e., from within the chasm). It is possible that providing an exciting view contributes to the appreciation of a PIR, as indicated by participants looking around more — neither of the other SPC PIRs provided a “better” view than the mountains. It is possible that understanding how spaces connect can offer an intrinsic reward similar to that of exploring EXPs. Out of all PIRs, caves were commented on fairly frequently (nearly as much as mountains). This suggests that they stood out to participants and left an impression. However, this did not translate into as many visits. It could be that fewer participants noticed the SPC PIRs.

Additionally, because their entrances are more hidden (while mountains were readily apparent), the effort to figure them out was perhaps too demanding for some. Games tend to implement this pattern not as a way to guide players but to present them with a challenge that often involves a reward. The fact that players looked around more when at these PIRs may also suggest they were looking for something. Since there was nothing to find (a fact commented on often by participants), it is possible players did not feel the need to bother with figuring out these PIRs once the lack of reward had become apparent.

7.4.4.4 Visual Obstructions (OBS)

OBS PIRs were visited the least of all patterns (with one exception), and players stayed the shortest. Considering the results of the spatial entropy measure, it would also appear that players primarily ran through these PIRs, possibly without even registering them. *Ground Fog* stands out as an exception, as it was visited by more players than any other individual PIR. It was also relatively often commented on by participants after the game. It is conceivable that the two dense forests were not understood as places for potential exploration but rather as natural boundaries. Of course, it is also possible that the potential was understood but not sufficiently appealing. A challenge in successfully implementing this pattern stems from the fact that visual obstructions must still appear surmountable. Games often enclose the interactive space with environmental obstructions that communicate to players that they cannot be overcome (which is also the case for the game in this study). OBS patterns can easily be misread as areas that cannot be explored. As a result, games tend to implement this pattern more often for secrets (i.e., additional content designed to be encountered by a small selection of players) and not to guide player progress. This would explain why this pattern was more likely to be explored by players with higher game experience. Based on having played other games, they were possibly better equipped to recognize the PIRs as potentially interesting. Alternatively, it could also be that less experienced players avoided the possibility of danger as their vision was obscured.

7.4.5 Impact of Trait Curiosity

As stated in *H3*, there was a possibility that a general disposition for curiosity (i.e., trait curiosity) would impact exploratory behavior. The study results show that curiosity dimensions did not correlate with exploratory behavior measures (except for camera rotation with *Thrill Seeking*) or emotional experience. Whether or not a player experienced curiosity for exploration in the game did not seem to be impacted by their general disposition. It is possible that the threshold for engaging in exploratory behavior in a game like this is relatively low or that measures of trait curiosity in the physical world do not correspond to game environments. Based on these results, *H3 must be rejected.*

7.4.6 Measures of Exploration

Measures in this study involved validated psychometric instruments (i.e., GUESS, 5DC), game metrics, and an exploratory in-game measure of curiosity that has yet to prove its viability in further game user research studies. Especially the use of in-the-moment measures of emotional states through a combination of a curiosity scale and interpreting the affect of emotion words has, to the author's knowledge, not been described to measure exploration in video games before. The study results suggest that in-game curiosity ratings correlated with how players assess their game experience. However, these ratings also showed a wide variance across players, suggesting that unexplored factors contribute to being in a state of curiosity. One weakness of the measure is that it was gathered at fixed points in time instead of taking measures at specific player actions or locations in the game.

The interpretation of emotion words provided a more substantial basis for evaluating affective states that accompany exploration than the curiosity scale. It can be hypothesized that curiosity in games may be a short state that is more difficult to self-assess than the use of emotion words. Ultimately, measuring curiosity remains a challenging task — it is either determined by indirect measures or measured by interventions that can impact the measure by their mere presence. Nevertheless, the results of this study provide evidence that a combination of behavioral and affective measures can present insights into curiosity for exploration.

7.5 Limitations

The results of any study should be considered within the limitations of its design. As stated previously, games are complex systems with many interacting elements. With the design of *Shinobi Valley*, one of the goals was to strike a balance between controlling for confounding factors while still giving players the experience of playing an entertainment game. However, this meant that the game lacked many typical characteristics of games featuring spatial exploration. Level design patterns are not usually used in isolation. Instead, they guide players toward specific objects, objectives, or interaction possibilities. As such, they are likely to raise expectations in players that their exploratory behavior will somehow be acknowledged or rewarded. This is shown in the study's qualitative data, which suggests that many participants expected to find something as the result of their exploration. While exploratory behavior probably was not impacted (due to the short duration of the game), emotional investment likely was because the game did not provide the satisfaction that entertainment games do. Since this study intended to investigate curiosity-driven exploration and not specifically to entertain players, this is considered acceptable. However, future studies should carefully consider implementing rewards (if it benefits their purposes), especially when player entertainment is the focus of the study.

Concerning this, there is also the matter of distinguishing between assured and potential compensation and considering potential compensation by way of a random draw as being different. Although there was a significant difference between the two forms of compensation, the possibility cannot be excluded that a *potential* extrinsic reward carried an effect of its own.

Another limitation that should be noted is that the patterns tested in this study were formulated based on the design of 3D, open-world games. As such, the results cannot be generalized to all types of games. However, the patterns can likely be implemented in different virtual environments (e.g., smaller, "closed" levels) and other game forms. It is, for example, possible to have hard-to-reach places or out-of-place objects in a 2D game. Their implementation will require careful thought, however, and whether or not they are experienced similarly as they were in this study remains to be investigated.

Even a game as simple as *Shinobi Valley* adds layers of complexity to empirical assessment. The decision to include additional variables, rather than only focusing on the presence or absence of level design patterns, complicated the study considerably. Testing the game with only one independent variable would have been easier but would also miss essential findings related to interaction effects with, for example, a stated goal. As discussed previously, level design patterns do not occur in a vacuum. Therefore, it was important to include at least some aspects integral to many games rather than draw conclusions from a very narrowly designed experiment. However, this makes the gathered results more complex to interpret, a challenge inherent to disentangling player experience. Future studies should be designed with an awareness of this challenge.

Another decision that could have had a negative impact was to have more participants play with patterns present to increase the sample size for that condition. Naturally, this skewed the sample sizes of the condition groups. It is generally recommended that the groups be of similar size when conducting ANOVA tests between conditions. Instead, some condition groups had relatively few participants. For example, the smallest combined condition group (no pattern, goal, nature, no compensation) had 5 participants, while the largest group (pattern, goal, alien, compensation) had 32 (in general: $Mn=16$, $SD=8.9$). Because of this range, any interaction effects detected in the data lend themselves to further study with more participants and should be considered in future work.

Another consideration in the study design was the decision to make participants wait after encountering the master. Although this decision provided interesting findings relating to how the stated goal and level design patterns interacted, it cannot be said that exploration while waiting happened solely due to curiosity and was not, at least in part, motivated by boredom. As stated previously, curiosity is challenging to capture. Although the study uncovered interesting results, it cannot fully interpret the motivations of players. Likely, they are multi-dimensional. More thorough in-game measures (e.g., observation, questions, think-aloud protocol) might assist with unpacking the player experience further. However, a balance must always be struck between an experiment's invasiveness and a measure's thoroughness.

Finally, the GUESS questionnaire was only carried out after participants completed the game. Players filled out the survey after possibly spending the final minutes of the game annoyed or bored. As a result, the GUESS was likely influenced by these final minutes and not particularly useful in assessing differences between conditions. Although the in-game measures offset this somewhat, these do not assess game experience as thoroughly as the GUESS. While making players wait provided additional opportunities for collecting data, the use of any post-game questionnaire should be considered carefully if a similar design is used in future studies. Even if the study design is different, there is an inherent challenge in relying on post-game measures when capturing temporary states, such as curiosity.

7.6 Conclusion

This study uncovered empirical evidence for level design patterns eliciting curiosity-driven exploration in players. The impact was affected by an explicit goal statement and whether assured compensation was provided. In the absence of such design patterns, players engaged in less exploration and formed fewer expectations about being rewarded for doing so. Involving a goal statement strongly impacted players' likelihood of engaging in exploration. Participants were most engaged in curiosity-driven exploration when patterns in the environment provided opportunities, and the game's goal was left sufficiently ambiguous to pay attention to the larger environment. Players' comments showed that game exploration is understood as a mechanic in itself. It can be concluded that the dramatic principle of *Chekhov's Gun* in literature (Rayfield 1999) also applies to elements that invoke exploration: if something promises to be an interesting area for exploration, it should provide acknowledgment to players when they do so. Failing to do so results in a negative emotional response. This is already a common practice in game development, and the exclusion of rewards in this study was primarily motivated by reducing confounding experiment variables.

Based on the experiment results, whether or not players explore was not impacted by their general disposition for curiosity. This could mean that the threshold for developing curiosity was not very high in the game experiment or that general disposition is not a strong predictor for a curious state in a video game. The study provided evidence that exploration motivated by boredom differs from curiosity-driven exploration. Additionally, curiosity-driven exploration can have different motivations, such as looking for rewards, interaction possibilities, or testing the environment's boundaries. Design patterns can only increase the likelihood of curiosity, not enforce it. By controlling for environmental aesthetics, the findings of this study should apply not just to this specific implementation but to other game environments as well. Finally, whether or not participants were compensated also affected exploratory behavior and should be considered, especially in study designs looking into player behavior and gameplay experience.

With this study, there is now empirical evidence for the efficacy of a design practice that is already common in video games. Based on the analysis of in- and post-game measures, the study provides a conceptual framework for understanding the impact of individual patterns and mapping their efficacy in light of related factors, such as having a stated goal or behavior during waiting time. Through an experimental design that incorporates and evaluates various elements common to games, the study illustrates many complexities that result from the interaction between such elements. Although this results in a more complex research narrative, it is an account that can inform future empirical studies of player experience and shows the need to explore variables whose influence may otherwise be ignored. This does not mean that every game research should incorporate a variable on whether or not players have an explicit goal.

Instead, designers and researchers ought to consider what effects their decisions might have on players, especially when studying player experience and complex emotional constructs.

Future work may expand on the lexicon of design patterns that invoke curiosity for exploration. Given the vast design space of creating game worlds, more data from different implementations of the discussed patterns is needed to support or scrutinize this study's findings. The promise of engaging in this work is a better theoretical understanding of how to design for curiosity-driven exploration intentionally. In time, such work can also support efforts for better procedural creation of video game content or even real-world implementations of explorable architecture, such as the design of playgrounds or amusement parks.

8 Academic Exploration Through Games

As discussed in Chapter 2, video games are frequently developed to fulfill an applied purpose beyond focusing on entertaining an audience of players. Indeed, the games developed in the studies described in Chapters 3 and 6 are such applied games. In the case of *CURIO*, the game can be considered fulfilling two different, if related, applied purposes: to serve as a Game-Based Learning (GBL) game for young students and teachers and to serve as a research tool for academics studying GBL or curiosity. *Shinobi Valley*, in turn, was entirely created to fulfill a research purpose. For games like these, this chapter proposes the term "academic games", as a way to describe the broader landscape of video games that have been developed or used in an academic context.

> The research question guiding this chapter's work is:
> **How can games be used as tools for academic exploration?**

Many participant-based experiments already resemble the formal structure of a game, involving tasks, goals, and measures for success, making games naturally suited as experiment tools (Washburn 2003). In some cases, this has led to the direct involvement of games in research projects. An early example is the game *Space Fortress*, which was used to attract participants and collect data that would be difficult to obtain without using a game (Mané and Donchin 1989).

In this chapter, academic games are understood as a sub-field of applied games and, more specifically, as *games that are used and developed within academic institutions for the generation, evaluation, or dissemination of knowledge*. Note that, with this definition, the focus is not on educational games, i.e., games that aim to teach or train the player in particular knowledge or skills. While academic games can have educational aspects or intentions, they are not required. The definition also does not focus on research about individual game titles, efforts that analyze their cultural impact, or matters of improving the player experience of specific game titles.

Although the literature on applied game (Schmidt, Emmerich, and Schmidt 2015) development is extensive, studies of games used for research purposes are sparse. This may be because such games were instrumental in researching "something else", making them less evident as objects of study. Therefore, this chapter focuses on such games and the academic context in which they are developed.

Firstly, the aim is to determine the fundamental purposes for using academic games. Insight into these purposes is critical for shaping informed guidelines and best practices for developing academic games and enabling a more targeted discourse for evaluating their efficacy. Four purposes are defined and further described: using games as *stimulus*, as *intervention*, as *incentive*, or to *model* processes.

Secondly, the chapter describes facets of game involvement. While the purpose describes *why* a game is involved, facets describe *how* that game interfaces with the academic context. The formulation of purposes and facets is based both on the study of existing work and on the authors' prior development and research experience across different academic fields. Case studies are discussed as illustrations and argumentative foundation for defining commonalities, differences, and how such games have been used. The described facets are *information flow*, *artifact dependency*, and *specificity requirements*.

The following sections elaborate on the definition of academic games, discuss what constitutes an academic context based on prior work, and outline the purposes and facets of game involvement in academic efforts. In presenting an initial inventory of both purposes for academic games and facets of their involvement, the chapter concludes with the foundation for a research agenda to improve the use and development of games for academic purposes.

Chapter Publications

Work presented in this chapter has been published in this peer-reviewed venue:

- **International Conference on the Foundations of Digital Games (FDG) – 2022**
  "Academic Games — Mapping the Use of Video Games in Academic Contexts"
  (M. Gómez-Maureira et al. 2022)

The chapter further references the following related work (co-)published by the author:

- **PLOS One – 2019**
  "A serious game to explore human foraging in a 3D environment" (Prpic et al. 2019)
- **International Conference on Entertainment Computing (ICEC Conference) – 2022**
  "Through Troubled Waters: A Narrative Game for Anger Regulation" (Li et al. 2022)

8.1 Defining Academic Games

Defining what is or is not a game is notoriously difficult (Arjoranta 2014), and this difficulty extends to the area of academic games. As discussed in Chapter 2, in this manuscript *games* are considered *intentionally bounded systems, designed to facilitate cognitively or affectively engaging scenarios through interaction.*

The view taken as part of defining academic games is that *the separation between what is or is not a game depends on whether a task or activity is framed as a game*. This framing exists separate from academically formal definitions of what constitutes a game and concerns what an involved stakeholder perceives as a game or expects from that framing. An activity might include many elements that suggest that a game is being played without being referred to as such.

Playing a game has been described as entering a "magic circle", a conceptual space and time shaped by a consensus of its participants to establish rules and rituals that apply within it. Within game studies, the metaphor of the magic circle, coined by Johan Huizinga (Huizinga 1971), is frequently used to discuss how a game context differs from the surrounding context; in essence, the "real world" in which a game is played. It is, in part, the framing of the context that shapes its perception. This explains why similar activities can, at times, be experienced as enjoyable or not, simply by changing the framing of the activity (Lieberoth 2015). As a result, academic games are, in a way, a part of many research projects, even if the researchers behind them do not necessarily explicitly mention that framing.

In experimental psychology, participants are frequently asked to carry out tasks within an intentionally bounded system (the lab setting) designed to cognitively or affectively engage them through interaction. Following various formal definitions (e.g., Avedon and Sutton-Smith 2015; Schell 2008; Salen Tekinbaş and Zimmerman 2003), such tasks could be seen as games. Emphasizing that framing can be beneficial for recruiting participants or can make mundane tasks more engaging.

What might contribute to game-like tasks being more commonly referred to as *experiment tasks* rather than academic games is that researchers might not consider themselves game designers. However, while game development often involves the work of dedicated game designers, *game design takes place whenever activities are carried out to develop a game, regardless of whether someone claims the title of designer.* Academics who involve games in their research may find themselves in the role of a game designer without realizing it, especially if participants conceptualize experiment tasks as a game or experience them as such.

As a result, academic games are not defined by specific attributes shaped by a game designer but rather by the overall perception of all stakeholders involved in an activity that takes place in an academic context. Intentional design can strengthen that perception by using design elements commonly associated with video games (e.g., referring to participants as players; notions of a high score, winning or losing). However, it is ultimately the framing of an activity that defines it as part of a game and the broader context that makes it “academic”.

8.2 Demarcating the Academic Context

With the popularization of video games as a medium for entertainment and beyond, academic endeavors have also increased their use for their purposes. In disciplines such as psychology or computer science, digital games are increasingly involved as research artifacts (Carlier et al. 2019; Levy et al. 2018; Risi and Preuss 2020); used to enable or support research goals that are not intrinsically connected to digital games as a medium. In these contexts, games fulfill the role of a research tool that, while potentially very effective, could be substituted with different approaches (e.g., a physical experiment). This stands in contrast to digital games as the object of study, as is often the case in *game studies*, a specialization within humanities and cultural studies (F. Mäyrä 2008), where games could not be substituted with other types of objects. The same holds for research in which games are both a research artifact and object of study, which can be the case in Game User Research (GUR), which seeks to generate knowledge from games as research artifacts for the benefit of games as a medium (Seif El-Nasr et al. 2012).

The academic context discussed in this chapter focuses on the utilitarian aspects of involving video games in research efforts that are not about the game itself. This includes research that can contribute to understanding player behavior, game experience, or technical advancements in general. However, it excludes efforts that analyze existing games regarding their cultural impact or matters of improving their own experience for players. The intention behind this omission is to understand the contribution that games can make to other academic efforts.

Earlier work by Ivory (2013) has proposed a typology of video game research approaches for studying the role of video games in social science contexts. They differentiate between "video games as stimulus" (effects on psychological states and behaviors), "video games as avocation" (motivations and personal consequences of playing games), "video games as skill" (game impact on perception, cognition, and motor skills), and "video games as social environment" (player interactions and relationships within games). While some of Ivory's proposed types can fit a focus on the utilitarian aspect of games for academic purposes, they are formulated with an emphasis on understanding video games as a medium. The demarcation of the academic context in this work argues that academic games are not confined to fields that study the medium but also use games as a tool for inquiry.

Video games created within an academic context are thus necessarily considered fulfilling non-entertainment purposes. Even when employing games developed initially to entertain, their use in an academic context renders them essentially "applied", regardless of the entertainment value that might be experienced when they are played. As such, the use of video games in academic contexts should be understood as a more closely defined use-case within the area of games for non-entertainment purposes, i.e., applied games.

An academic context is established if involved *stakeholders conduct their work as part of education and research institutions to develop knowledge.* This context does not require that game involvement itself needs to be part of developing knowledge. Games might be created or used to disseminate knowledge developed within those institutions. This is because the academic context does not only consist of activities that are epistemic in nature. *It also consists of the discourse surrounding such activities, as well as logistical, political, and financial efforts to improve the conditions of academic institutions.*

Games are widely seen as a medium that provides enjoyment and entertaining experiences. This can make the involvement of games enticing for shaping public perception about a field of research or connected institutions. An example is the use of *Minecraft* (Mojang 2011) for demonstrating archeological sites (Politopoulos et al. 2019). Simply put, if games are fun, perhaps they can make any connected activity seem fun as well. Such cases share considerable similarities with advergames, only with the use-case being part of academic institutions instead of for-profit corporations.

Game involvement as part of supporting institutional efforts, such as shaping public discourse, necessarily depends on the existence of an institution to support. Equivalent cases could be considered as the corporate use of games, such as business-to-business games (Michaud and Alvarez 2008), but fall outside the academic context. However, the efforts of corporations can and do enter the academic context when intellectual output is created for academic purposes (such as through peer-reviewed publications).

8.3 Purposes for Involving Games in Academic Contexts

Research involving games often takes place within interdisciplinary teams and thus tends to involve varying intentions and perspectives of individual stakeholders. Such differences, if left unaddressed, can impact the project in unexpected ways. The value in determining the purpose of game involvement is to align perspectives and better shape the subsequent game development efforts and goals.

This section describes four proposed *fundamental purposes* for involving video games in academic contexts: *stimulus*, *intervention*, *incentive*, and *modeling*. These purposes are informed by case studies in contemporary literature and studies carried out in previous chapters. The qualification of a purpose being fundamental is meant to hint at the fact that purposes are not entirely mutually exclusive. Multiple purposes can and do co-exist. However, while research efforts might include multiple fundamental purposes, this can present challenges in ensuring the game lives up to all of them.

Each purpose is first described in terms of what defines it and how it differs from other fundamental purposes. This is followed by prior work that exemplifies the purpose. Examples might explicitly mention the purpose or are ascribed to one of the purposes based on the properties of the work.

8.3.1 As Stimulus

Playing a video game often requires attention and navigational skills or invokes emotions such as happiness, anger, or curiosity. It causes a reaction in the player based on the scenario established by the game. *Whenever a game is used to cause a measurable reaction or change in the player, and the research context is interested in monitoring and measuring that change, the game's purpose is to use it as a stimulus*. In such a case, the game is ideally selected or specifically created to maximize the likelihood of eliciting the intended reaction.

When a game acts as a stimulus, players generate data through their actions in the game or by having played the game before measures are taken. A defining aspect of games as stimuli is that data depends on the specific game context and is created due to a change occurring within the player. A change in the game can therefore result in a change in the measure, based not only on the quality of the game implementation but also on how it is designed.

One example of a stimulus game is *Squirrel Away* (Prpic et al. 2019), a single-player tablet game for studying human foraging behavior. In the game, players take control of a squirrel gathering food in a virtual park from a first-person perspective. Players are tasked with collecting "target" objects among "distractor" objects, both scattered across the virtual environment. The game allows researchers to replace the images

Figure 8.1: Screenshots of example stimulus games, from left to right: *Squirrel Away* (first two images), and *Affective Pacman*.

used for target and distractor objects, as well as modify the ratio and overall amount in the game.

Another example that illustrates the use of a game as an experiment stimulus is *Affective Pacman* (Reuderink, Nijholt, and Poel 2009), a modified version of the classic arcade game designed to study the impact of frustration on brain activity (EEG measures). For the study, the researchers created a version of *Pacman* in which the game randomly ignores part of their input, and visual output is randomly withheld for a few frames. The modification is designed to appear as a technical issue instead of an intentional stimulus. Although these issues are triggered randomly, they are controlled, can be tracked, and thus allow for analyzing the impact on brain activity. The game could also be used in studies investigating affective responses and illustrates the use of video games as emotion elicitors (Karpouzis and Yannakakis 2016).

Using games as stimuli is common in psychology and related fields (Porter 1995; Gray 2017), given that the focus is on changes in the player caused by a game artifact. Compared to non-game stimuli, games are lauded for their potential to increase motivation and performance for completing research tasks (Donchin 1995). Games are also considered to have the potential to act as ecologically valid experimental environments (Järvelä et al. 2015), partly because framing a task as a game makes it more likely for participants to discount aspects that are not part of the game space.

Studies about cognitive or emotional states, for example, typically require participants to enter such states in a lab environment that may not be conducive to eliciting them naturally. Invoking familiar properties of games that mark the transition into a “magic circle”, i.e., into a make-believe space, helps participants enter the states of interest for the study. In doing so, games act as a stimulus for a change in the psycho-physiological state.

The game *Shinobi Valley*, developed as part of studies described in the Chapters 6 and 7, is an example of an academic game that was created to serve as a stimulus.

8.3.2 As Intervention

While stimulus games are concerned with inducing a short-term response in the player, specifically to be measured for research purposes, interventions are concerned with causing a long-term change in the player *for their benefit*. This type of game has also been described as “transformational”; as games designed to change players (Culyba 2018). The *Transformational Framework* describes types of transformation, such as *knowledge*, *disposition*, *physical*, or *behavior*, to name a few. However, in this thesis, a game designed to change behavior falls under a different type of academic game than one designed to study it, as is the case for stimulus games. Examples of academic games designed to act as intervention include those made for therapy purposes (e.g., in health care Kato 2010) or supporting habit changes.

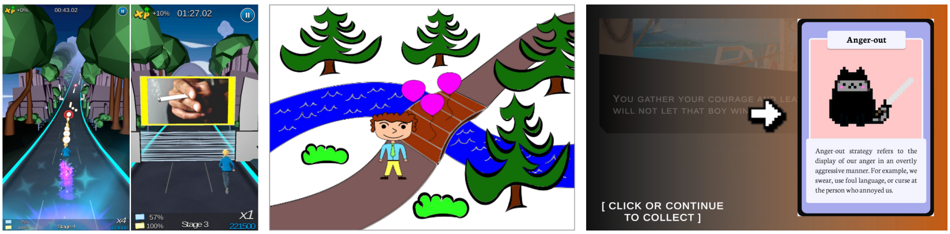


Figure 8.2: Screenshots of example stimulus games, from left to right: *HitnRun* (first two images), *Speech Adventure*, and *Through Troubled Waters*.

An example of an intervention game is *HitnRun* (Scholten, Luijten, and Granic 2019), a single-player mobile game based on “endless runner” games such as *Temple Run* (Imangi Studios 2011). The game incorporates target and distractor objects showing smoking-related or neutral images. The game’s goal is to decrease the desire to smoke by creating a negative association with smoking-related imagery.

Another example is *Speech Adventure* (Rubin and Kurniawan 2013), a speech training game for children with a cleft palate or cleft lip. The game features speech recognition capable of discerning mispronunciations due to cleft speech problems. The game takes the form of an interactive storybook in which words must be pronounced correctly in order to progress.

Another example of an intervention game is *Through Troubled Waters* (Li et al. 2022), a branching narrative game that shows players different ways of dealing with anger in everyday life situations. The game supports players by providing labels for anger-related emotions. It introduces them to different coping mechanisms they can use as part of the game narrative to see how situations might resolve.

A game might act as a catalyst for change, but the game does not exist in order to measure the change for research purposes; instead, it exists to elicit it for the player's benefit. However, to develop games that can act in such a capacity, measures must assess whether the intended change is taking place and whether the extent of the change justifies the effort compared to non-game interventions. Projects with the eventual aim to develop a treatment or intervention are thus likely to start with laboratory experiments in which the game or parts thereof act as a stimulus. In most cases, it is not the academic partners in such projects that will eventually release the game. Instead, this happens with the collaboration of industry partners once the game has been proven effective.

> The game *CURIO*, developed as part of the study described in Chapter 3, is an example of an academic game serving an intervention purpose.

8.3.3 As Incentive

Another fundamental purpose for involving games is to tap into the widely held perception that games are entertaining. For those who enjoy playing games, executing an otherwise undesirable task might appear appealing if it is framed in the context of a game. In such cases, games are involved for their potential to incentivize as a reward for executing a task.

This might involve collecting measures that are created as part of the game. In contrast to pure stimulus games, however, the collected data results from a task being executed rather than a change in the player specifically elicited through the game's design. Changes in the game may impact how effective the game is in its ability to incentivize players to perform a task. However, it does not meaningfully impact the data that is being generated.

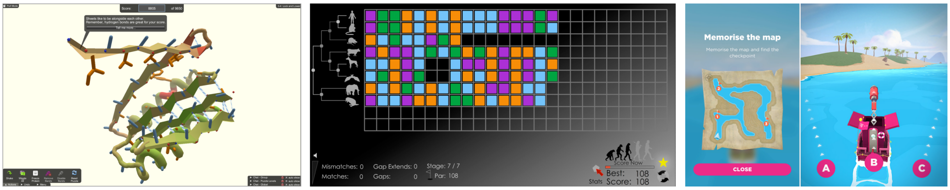


Figure 8.3: Screenshots of example incentive games, from left to right: *Foldit*, *Phylo*, and *Sea Hero Quest* (last two images).

Games can be used as an incentive to collect or process data. Citizen science games are good examples where gameplay provides an incentive for executing scientifically valuable tasks. The game *Foldit* (UW Center for Game Science 2008) tasks players with optimization puzzles based on the real-world protein folding process. Rules in the game are designed to work analogous to the biochemical reactions that impact the three-dimensional structure of proteins. By playing the game, players are working on organizing protein structures in a manner that is meant to predict how a protein structure would fold, given its amino acid sequence. In doing so, they create data that can be used to train computational strategies and highlight structures that warrant more detailed research.

A similar example can be found in the game *Phylo* (Kawrykow et al. 2012) for multiple sequence alignment optimization in DNA sequences or in *Sea Hero Quest* (Spiers, Coutrot, and Hornberger 2021) for collecting data on navigation behavior for researching Alzheimer's disease. In these examples, participants are tasked with processing or creating data on a large scale. By framing tasks as a game, participants, now players, are given an incentive to complete a task. Their participation provides a service for scientific studies. However, in the short term, they are incentivized by progressing a game narrative, competing against other players, or by game-based feedback, such as an in-game scoring system, to improve their performance. The tasks could, however, be executed through other incentives, such as monetary rewards, as is the case in crowdsourcing platforms such as *Amazon Mechanical Turk* (Shank 2016). Although the game context holds the promise of establishing an intrinsic motivation (Rheinberg and Engeser 2018) for task completion, it depends on the participant's interest in the context and their ability to enter and leave the context freely. If participants are not interested in the game context or perceive it as a chore that must be completed, the game context risks becoming little more than a work task with extraneous elements attached to it. It is worth noting that even if a task is experienced as being enjoyable, its completion quality might not necessarily improve (Hawkins et al. 2013).

Another use case for involving games as incentives is educational games developed within academic contexts. The topics of such games are likely to target specific topics that are not covered by commercially available education games. Games in which the education material exists to a large extent separately from the game mechanics use the medium of games as an incentive to play. In such cases, the material does not uniquely benefit from being conveyed through a game but makes it more likely for players to engage with it.

One example is the mobile game *Herbopolis* (Ee, Yap, and Yap 2018), which aims to educate players about herbal medicine. In the game, players are tasked with operating the business of growing, processing, and selling herbal medicine. The game's purpose is to educate players about the appearance of herbs and concepts of potency and dosage. Additional aspects, such as managing a business, exist to facilitate (prolonged) engagement with the game. The purpose of educating about the appearance, potency, and dosage of herbs could be communicated without using a game. Most actions in the game are arguably more synonymous with the tasks and challenges of running a farming business. However, the game frequently exposes players to educational content, even if the game's mechanics are more likely to educate them about business principles. The game mechanics thus provide an incentive to engage with the educational content.

Education games that seek to incentivize players by their game context are often aimed at children to make educational content appear more palatable. However, educational games can be designed to convey educational content through play. In such a case, games are not only (and perhaps not even primarily) used for their ability to incentivize but to make a subject experientially understandable. This purpose is closer to *modeling*, which is described in more detail in the following subsection.

8.3.4 For Modeling Purposes

The involvement of a game can be motivated by the desire to understand a phenomenon by constructing or experiencing it through a game. Modeling can take place on a conceptual level or be an attempt to simulate a topic of interest as accurately as possible. When involving a game to model phenomena, the game's processes are the study object. It concerns the evaluation of the sum of actions that happen as part of the game that is being played. This purpose differs from the previous three in that the research focus tends to lie with the system more than the player or that no player is required at all.

Within technologically-minded sciences, modeling usually refers to the practice of simulating processes with computer algorithms. For categorizing the fundamental purpose of involving games, modeling should be understood more broadly. It refers to the process of building knowledge by observing or interacting with a simplified artifact that acts as a representation of a more complex phenomenon. That artifact can be actual, such as a physical miniature or a virtual representation of a physical environment. It can also be conceptual, such as a hypothetical thought experiment, as in the game *Something Something Soup Something* (Gualeni 2017, 2018), which asks players to reflect on the mutable nature of definitions. In the case of academic games, modeling primarily means to create or modify a game and thus make it an actual artifact, even when used as a thought experiment.

Games, especially well-known ones, can provide an experiential understanding for interpreting results or implementing modeling parameters. It allows researchers to use game-specific terminology to explain and understand modeling outcomes. Optimizing parameters can, for example, be framed as winning or losing. Interactions in the game, especially those of individual entities, can be discussed through the metaphor of incentives, goals, and desires. By using games, such features can be communicated so that other researchers and the general audience understand more easily. Enemies compete with a player character; collectibles such as coins or food are objects of desire; deep pits pose a danger for the player but can be surmounted; and so on.

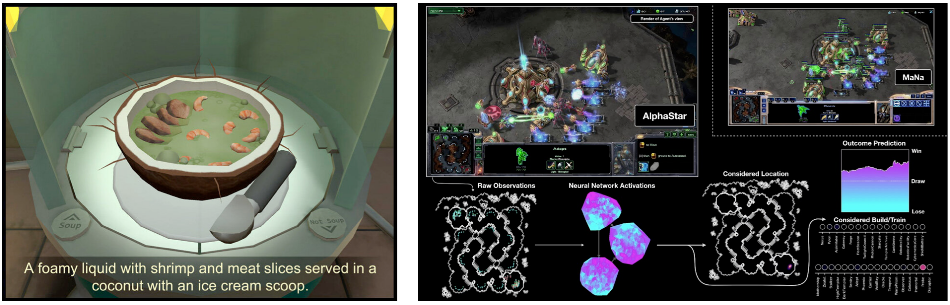


Figure 8.4: Left: Screenshot showing the game *Something Something Soup Something*. Right: Freeze frame image of the *AlphaStar* agent visualization.

Examples of using games for modeling are often found within computer science and related fields, such as artificial intelligence research. Efforts to solve games, i.e., identifying the most optimal decision a rational actor can take, provide testing grounds for computational strategies in uncertain or complex environments.

The development of *AlphaStar* (Vinyals et al. 2019) involves the real-time strategy game *Starcraft II* (Blizzard Entertainment 2010) in which multiple entities are controlled as virtual armies to fight against other players with their armies in complex virtual terrain. Due to the real-time nature of the game, the state of the game changes from moment to moment, thereby restricting the amount of time that can be taken to evaluate optimal actions. The purpose of involving *Star Craft II* in this example is to study and improve the development of intelligent programs through a complex environment. Using a game that can be played against a human player allows for evaluating the program, not on individual parameters, but given its performance through the sum of actions in the game.

The use of games for modeling purposes might not even require a player's participation in the traditional sense. Instead, a game serves as a simplified testing ground, such as using Atari games like *Pong* (Atari 1972) to train and compare computational models (Tampuu et al. 2017; Cui et al. 2020). Instead of attempting to solve such relatively simple games, they serve as a benchmark. A game artifact is involved because it provides a clear, comparable experimental condition. The only player in such a case is the computational system, playing with (or against) itself, resulting in a sort of "zero-player game" (Björk and Juul 2012).

As mentioned in the previous subsection, educational games may be motivated by a desire to make content more memorable by allowing players to engage with it playfully. Sandbox games such as *Minecraft* provide players with large environments and rule-based interaction mechanics that can be used for a wide range of educational topics. Based on this, the game is available as *Education Edition* (Mojang Studios 2016), giving educators a tool for shaping educational experiences in which players learn through their engagement with the game. That is not to say that all educational content mediated through *Minecraft* is automatically so connected to it that the game is an integral part of understanding a phenomenon. One can conceive a *Minecraft* environment littered with signs that educate players on a topic by having them read through all of them to convey knowledge. Doing so uses *Minecraft* as an incentive to read the content but does not require meaningful engagement to understand it better.

Figure 8.5: Screenshots of *Minecraft*, from left to right: *Minecraft Education Edition* (first two images) using the science kit and code builder; *RoMeincraft* (last image) showing the Roman fort in modern-day Leiden in The Netherlands.

A counterexample of this use of *Minecraft* can be found in the game project *RoMeincraft* which uses *Minecraft* as a platform for collaborative play between archaeologists and members of the public (Politopoulos et al. 2019). The project reconstructs Roman architecture by using the virtual space of *Minecraft*, providing players with a space to explore and expand it. Rather than educate specific points of knowledge, the project seeks to encourage interest in Roman heritage, using *Minecraft* as a tool to induce curiosity about the topic. Although the context of the game surely acts as an incentive to engage, the purpose of involving *Minecraft* is to gain an experiential understanding by playing it.

8.4 Facets of Games in Academic Contexts

Whereas the previous section outlined why a game might be used, this section focuses on how it interfaces with the academic context. Three facets are described:

- Information flow between game facilitators and players
- Dependency of the academic context on the game artifact
- How specific an artifact needs to be

These facets are not meant to cover all ontological features in any academic endeavor involving games. However, they are considered critical topics for discussion when planning to use games for academic purposes.

8.4.1 Information Flow

Every game used in an academic context involves an exchange of information. Players receive information, such as how the game is played, what actions can be executed, or are introduced to out-of-game information using the game as a medium (for example, in text boxes overlaying the game interface). Facilitators of the game (e.g., researchers, educators, game developers) may receive information through the act of it being played; either during the activity itself (through the logging of play data) or through a subsequent activity that is impacted by the game artifact (e.g., a survey or interview).

The *information flow* facet concerns what information is exchanged through a game artifact and which direction is dominant for each piece of information. Additionally, a sum could be made of the overall direction for the entire game.

Not all information exchanged through a game relates to the fundamental purpose of the game. For example, while information on game controls is necessary for the player to receive, it is generally not specific to the academic context. However, this information can affect the research outcomes. This was indeed one of the findings of the study involving *Shinobi Valley*; discussed in Chapter 7. As such, there is a scale of relevance to the academic context for all information passed through the game. The framing of the game's purpose and related information is considered critical, while functional information (e.g., controls) is generally less important. Nevertheless, both potentially influence how the game is perceived and eventually played.

Information flow towards a game facilitator is *information acquisition*. A game used to acquire information can collect data generated by playing it or eliciting a reaction in players that provides information. Games such as the aforementioned *Foldit*, *Phylo*, or *Sea Hero Quest* (see section 8.3.3) are examples developed to acquire data from players. While they might impart some knowledge to players, this is motivated by the desire to capture as much data from players as possible and ensure that the quality of that data meets the project's requirements.

Information flow coming from a game facilitator should be considered a form of *information dissemination*. In such cases, a game is used primarily to educate players or to communicate an argument. Additionally, it can be to instruct players as to how a game is meant to be played.

It may involve measures regarding the efficacy of the dissemination effort, still emphasizing that the leading intention is to disseminate information rather than to collect it. Game-based learning initiatives such as *Ludwig* (ovos realtime3D GmbH 2013; Wagner and Wernbacher 2013) or *CURIO* (discussed in Chapter 3) are examples of games that disseminate information. These games inform about a topic (as with *Ludwig*) or inform educators through a teaching toolkit (as in *CURIO*). Games meant to fulfill therapeutic purposes should also be considered as disseminating information in terms of their development purpose (requiring data acquisition primarily to validate their efficacy). As mentioned in section 8.3.4, games can also serve as artifacts for thought experiments. Here too, information is primarily directed toward a player rather than a game facilitator.

It is important to note that information flow may not always land squarely on either acquisition or dissemination. Games may be used for both purposes. *Sea Hero Quest*, for example, can also be considered as disseminating information by raising awareness about dementia research. Likewise, games created to impart information may require significant data acquisition to evaluate whether that goal is met. The value in thinking about information flow is to shape the development of a game (or its purposeful modification) accordingly.

In practice, even if a game is meant to acquire data, it might not require much development effort to provide additional information about the research context beyond the need of acquisition efforts. This may not only be in the interest of research transparency but also argue for the importance of the research field it is part of. On the other hand, game development (including the modification of games) is resource intensive. It thus warrants intentional emphasis on whether an artifact is meant to acquire or provide information.

8.4.2 Artifact Dependency

While some academic efforts may entirely depend on a specific game, in other cases, it may be that the use of games makes it easier to attract a larger number of participants. Games can be a valuable addition to research projects, even when they do not fully depend on them. However, being aware of their importance and reaching an agreement about that among all stakeholders helps to ensure that development resources are well distributed.

The involvement of a game can range from being mere *supportive* to being *catalytic* for an academic effort. As a catalyst, a game guides the design of the academic context just as much the other way around. For instance, studying exploratory behavior in video game environments, as in *Shinobi Valley*, is dependent on the involvement of a game in which participants can be observed while exploring such an environment. Research into virtual foraging behavior using a video game, for example (Prpic et al. 2019), could be considered somewhere between the two ends of the spectrum, given that a virtual environment does not entirely necessitate a game context. Studies may require using virtual environments to create experiment circumstances that can be easily replicated. Other times they are needed to elicit and observe behavior in scenarios that would be unethical, dangerous, or impossible to expose participants to in reality. Such virtual environments or simulations can be designed or framed as games. Often, however, the simulation of the situation is the study focus rather than the elements that make it a game.

Games are in a supportive role if the task or measure they are part of could be carried out without their involvement. This may be because a game artifact acts as a form of incentive for participation that could be fulfilled through financial compensation or other extrinsic rewards without significantly impacting the quality of the research. This is not to say that supportive games are involved arbitrarily. Using a game might, for example, attract more participants than a non-game implementation and thus add real value.

8.4.3 Specificity Requirements

Aside from the question of how dependent a project is on the involvement of a game artifact; it is also essential to consider how specific it should be. If an existing game can be used with little or no modifications, its specificity requirements for the academic context are low. The specificity, in this case, does not depend on a wide range of possible options. Instead, it regards how much design and development effort will be required to involve a game artifact in the academic project.

A high degree of specificity is warranted if few existing games could be modified to fit a research task or if it is in the interest of the project goals to create a specialized game artifact. This could be to avoid pre-conceived ideas if a known game is modified, to gain complete control over all parameters, or to promote an academic endeavor through an original game, as might have been the case in *Sea Hero Quest*.

While creating a game specifically for an academic effort can be tempting, doing so comes with additional challenges. Although game development has become increasingly more accessible, it remains a time-consuming activity in which not all tasks directly benefit the larger academic context. The effort required just to implement basic functionality such as virtual camera control, or player-character controls is easily overlooked. Minor imperfections in the execution of academic games can also be harder to ignore for participants if they compare them to more sophisticated commercial implementations. This is especially noteworthy if a game is meant to act as an incentive, as the perception of what games are and ought to be necessarily exists in context with what games are commonly available.

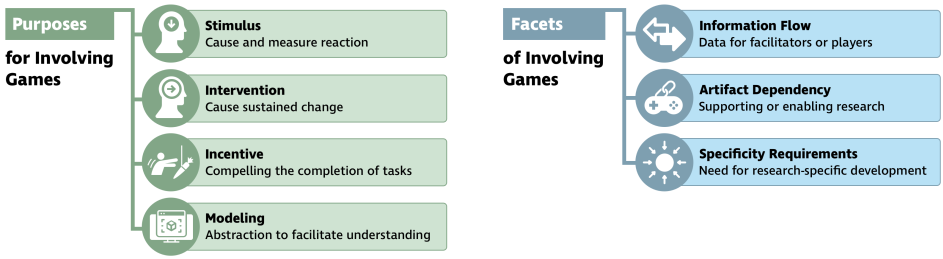


Figure 8.6: Diagram of fundamental purposes and facets for involving games in academic contexts.

8.5 Towards a Research Agenda

The purposes and facets defined in this chapter, visually summarized in figure 8.6, are meant to support early discussions and decisions in academic efforts, especially when several stakeholders are working together. Periodic evaluation of whether the facets are still used as initially intended can also be helpful. As a project develops, new ideas and considerations can enter the development process, possibly moving it in another direction. Although this does not necessarily pose a problem, practitioners must be aware of such changes, how they may impact the game artifact, and, in turn, the research effort.

At this stage, the proposed purposes and facets do not comprise the full extent of all considerations that come into play when games are used in academic contexts. However, they are defined on the basis that all academic efforts should be able to address them before moving on to more concrete development steps. Additional development support can be found in frameworks that are meant to aid with the creation of applied games (Tsita and Satratzemi 2019; Ávila-Pesántez, Rivera, and Alban 2017), although future work should aim to examine which approaches are more or less valid for academic contexts. Previous work has made strides in outlining challenges and guidelines for developing stimulus games (Järvelä et al. 2015) or identifying fitting games (Raffert, Zaharia, and Griffiths 2012; Mohseni, Liebold, and Pietschmann 2015), so a basis exists from which to expand the field of academic games further.

The analysis and identification of fundamental purposes and facets of game involvement in this chapter form the foundation for a research agenda to improve the use and development of games for academic purposes.

Future work on this agenda should investigate:

- To what extent prior work on applied games and game design requires specialization to fit the academic context better.
- How different academic fields approach the involvement of games for research purposes, e.g., through the mapping, discussing, and combining (individual) case studies.
- What stakeholders are most often involved in the use and creation of academic games, what they expect from the use of games, and how they influence decision-making.
- The formulation of development guidelines, frameworks, and tool-kits aimed at academic games.

As games increasingly involve user-generated content, e.g., in *Roblox* (Roblox Corporation 2006) or *Super Mario Maker* (Nintendo EAD 2015), and development tools continue to become more accessible, the use of games for non-entertainment purposes will likely continue to grow. Whether research or education, the academic context has already benefited from this trend. As this trend continues, academics will find themselves filling roles that are new to them. This chapter documents some of the efforts that have been conducted on this path and argues for the need to create knowledge specific to using games in the academic context. Rather than turning academics into professional game developers, the aim is to establish a better understanding of using the medium of games and shape it to their specific needs.

Ultimately, academic games are similar to entertainment games, and much of the lessons that apply to one will also apply to the other. The academic context does not turn them into an entirely different medium. Nevertheless, the context that games are a part of impacts their creation and those who play them. After all, the “magic circle” metaphor does not describe a hard border defined by metaphysical rules but rather one shaped by the surrounding context. Ignoring this risks losing the *magic* that is the experience of playing games. Addressing and embracing that context, on the other hand, can help improve discourse, bridge efforts across fields, and lead to professionalizing academic game development.

8.6 Conclusion

This chapter defined the use of games for academic contexts ("academic games") as a sub-field of applied games shaped by a purpose and the involvement of stakeholders from research and education institutions. Based on examples of prior work in that context, four fundamental purposes for using games are identified:

- as a psycho-physiological stimulus
- as an intervention mechanism
- as an incentive for completing tasks
- as a modeling platform to facilitate understanding

Making the purpose for game involvement explicit is especially important in the planning stages of an academic endeavor. Game development requires the collaboration of several stakeholders, some of whom might be more attuned to the academic content, while others focus more on technical or logistical considerations. In such cases, it is crucial to explain why a game is created or modified and to discuss these assumptions openly among all stakeholders. Indeed, the complexity of game development and research design can easily focus too quickly on more detailed matters, bypassing an explicit, shared agreement.

In addition to purposes, facets of game involvement are defined based on how games interface with the academic context that they are a part of: *the flow of information, dependency of an academic effort on a game artifact, and the specificity of the game artifact for the academic effort.* These facets are defined to provide a basis for making decisions on how to develop, select, or modify a game artifact to fulfill the purpose of its involvement.

This chapter contributes to the study of applied games and any field that may use games as tools for academic exploration. It has proposed academic games as a new sub-field of applied games, formulated the purposes and facets of academic games, and provided directions for their future study. It thus addresses the primary research question: *How can games be used as tools for academic exploration?* In doing so, it forms the basis for the professionalization of using games for academic study across disciplines.

9 Conclusion

Video games have become a medium of considerable cultural importance capable of many affordances, including enticing players into various forms of exploration. With these possibilities, they have become objects of study and tools for studying other subjects. This thesis investigated different forms of exploration in and through video games, laying a foundation for further study of this subject.

Initially, this work started as an investigation of curiosity and how it may be elicited purposefully through games (referring to "video games" specifically and used as a short form for brevity in this thesis). Over time, that question led to many others surrounding the topic of curiosity and the accompanying exploration behavior. Each turned out to be a multifaceted topic in its own right, further complicated by their interaction with the multidisciplinary nature of video games as a medium, shaped by aspects of, e.g., player psychology, design, art, and technology. As investigations into these topics progressed, another observation was made: namely, that the games created to study this topic were, in themselves, facilitating exploration for the researcher as well.

This process resulted in the different topics that this thesis encompasses. Research is not a straight line from start to finish but a road with twists and turns through changing circumstances and discoveries. This cannot always be acknowledged in separate publications, where the focus lies on presenting results under repeatable conditions within a maximum page count. However, it is vital to note this in the context of this thesis. While a straight-lined approach might have resulted in more actionable knowledge for game designers, the broader perspective taken in this thesis provides a first comprehensive look at the topic of curiosity-driven exploration through games in its many forms and complexities. It serves as a starting point for academics of many backgrounds interested in using games for their academic pursuits and provides a solid foundation to create actionable, generalizable knowledge.

9.1 Research Questions Revisited

The thesis aimed to answer the main research question: *How do games facilitate exploration?* The following sections will discuss the subquestions, after which the main question is addressed.

9.1.1 Conceptual Exploration

The first research question was: *How can a game facilitate conceptual exploration?* This question was the starting point for a practical investigation of game design focused on a particular notion: whether and how a game could elicit a player to become curious about a topic, with the external expression of that curiosity being the exploratory behavior of asking questions.

Chapter 3 answered the first research question with the design and implementation of the *CURIO* gamekit, in which players must ask critical and original questions through a narrative context. Through discussion, they are then encouraged to consider those questions more deeply. This case study illustrates how games can facilitate conceptual exploration.

With the case study of *CURIO*, the potential of games to stimulate questions and thought becomes explicit. It also showed how important it is to “manage” the information gap when designing for curiosity. While this responsibility was delegated to the teacher in the case of *CURIO*, it would usually rest with the game designer. *CURIO* could serve as a testing tool for further examination into where the balance in this lies (i.e., too much versus too little information).

Other areas of investigation could relate to different implementations of game designs. Such designs could include questions and discussion as core mechanics, investigating games with meta-narratives that promote reflection, or mechanics that cause the player to think critically.

CURIO formed the starting point of further investigations into curiosity. While this project focused on conceptual curiosity, it quickly became apparent that, within game design, different forms of curiosity are unlikely to exist in a vacuum. Thus, this case study formed the basis for further investigation of game types and the next research question.

9.1.2 Game Types

While the first question formed a starting point for the investigation of exploration through games, it was also a purposefully simplified implementation of exploration in a primary education context. Thus, Chapter 4 expanded the view on games and exploration by answering research sub-question 2: *What types of games elicit exploration?*

This question was addressed through an extensive survey in which players could rank and suggest games based on how curious they made them feel. Popular releases of the past years were ranked against each other, providing an idea of what type of gameplay is considered the most successful at eliciting curiosity. Connections were also made with the Five-Dimensional Curiosity Scale (5DC) questionnaire to group games under specific types of curiosity and allow players to suggest specific titles for certain types of curiosity. This study established a corpus of games players considered successful at eliciting various forms of curiosity.

The result shows that the answer to the research question is multifaceted, as games are complex systems that may elicit curiosity (and the resulting behavior of exploration) in various ways through design. The study found that the games *Zelda: Breath of the Wild*, *Elder Scrolls: Skyrim*, and *Portal* were ranked as the most successful in eliciting curiosity. Within these, the genre labels *Exploration*, *RPG*, and *Puzzle* are most representative of what activities in the game elicit curiosity. Among games suggested by participants, the genres *Social Sim*, *Collecting*, *RPG*, and *Exploration* ranked the highest and thus provided evidence that the potential of *Puzzle* games to elicit curiosity is highly dependent on the game. It was also established that what makes a player curious in a game is not necessarily related to their trait curiosity. Finally, while factors of age and gender may influence curiosity in games, individual game titles were similarly received despite these factors.

In answer to the research question, it was hypothesized that games that strike a balance between uncertainty and structure tend to rank high in eliciting curiosity. In contrast, highly deterministic games (requiring only cognitive or physical aptitude) or dependent entirely on chance tend to rank lower in curiosity. Exploration, in turn, requires a combination of guidance through game design and agency to shape one's own experience. What kind of exploration occurs and whether it is expressed through measurable behavior in the game or on a conceptual level depends on the game's design.

9.1.3 Design Patterns

After assessing what games players consider particularly effective in eliciting curiosity, Chapter 5 further analyzed these games in how they operationalize curiosity to result in exploration. This was done by understanding "design patterns", addressing research question 3: *What design patterns can be hypothesized for games that elicit exploration?*

Three types of curiosity-based exploration were examined in more detail, using game titles suggested in the survey study: conceptual, social, and spatial exploration.

Conceptual exploration was best comprehended through the genre of puzzle games, which invoke the notion of being able to solve a given problem within a set of rules and circumstances. While this can elicit conceptual exploration by aiming to solve the problem within the given design space, game designers can inspire further reflection by playing with the framing of such issues. For example, by unexpectedly changing the rules, a player may further wonder about information being withheld from them. Such conceptual exploration may also come from wondering about the consequences of actions or the meaning of choices in a game's narrative.

Social exploration behavior results from a curiosity for other players or virtual characters, examining their responses to situations, or building stories around them. Strategies discussed for eliciting such curiosity were, for example, performing mundane tasks giving a glimpse into a character's world, offering or restricting communication with other players, or building and shaping a personal character.

Spatial exploration refers to how a player is guided into traversing a virtual environment. For this exploration, five design patterns were defined for further study. These patterns are: *Reaching Extreme Points*, *Resolving Visual Obstructions*, *Out of Place Elements*, *Understanding Spatial Connections*, and *Desired Object Foraging*. These five patterns were not formulated to provide an exhaustive list of design strategies but rather as a step toward the empirical study that can assess the efficacy of hypothesized patterns.

9.1.4 Design Pattern Implementation and Validation

The previously formulated design patterns formed the basis for an empirical study assessing their efficacy in eliciting spatial exploration in Chapters 6 and 7. For the patterns to be tested in this manner, they first had to be implemented in a research game that could be used to measure and log player behavior. This process of implementation and validation served to answer research questions 4 and 5: *How can design patterns for exploration be implemented for validation?* and *How do design patterns for exploration influence player behavior and experience?*

These research questions were addressed by creating a research game designed to implement the design patterns for testing variations in level design and empirically measuring how they affected player behavior. The game had to provide opportunities for gathering behavioral data and operate reliably for use in an experimental study. Most importantly, it had to be successfully validated in its efficacy to motivate exploration through patterns. To this end, a pilot study was conducted that examined all these aspects.

Following the pilot study, an empirical study was conducted where the focus was on the empirical evaluation of the design patterns for spatial exploration. Design patterns were hypothesized to elicit more exploratory behavior (compared to if they were not present) and positively affect the player's emotional experience. It was further hypothesized that having an explicit goal would reduce exploration and that players with a higher predisposition for curiosity would explore more.

All patterns were shown to be effective at eliciting exploratory behavior. Participants were most engaged in curiosity-driven exploration when patterns in the environment provided opportunities, and the game's goal was left sufficiently ambiguous to pay attention to the larger environment. While players understood exploration to be a core part of the game, a lack of acknowledgment during exploration could negatively impact their experience. Whether or not players explored was not linked to their predisposition to become curious.

9.1.5 Games for Academic Exploration

The work performed to study exploration in video games also required the development of two games created to pursue academic knowledge. This form of "exploration" through games thus examined research question 6: *How are games used as tools for academic exploration?*

This part of the work proposed a definition for "academic games" as games used and developed within academic institutions to generate, evaluate, or disseminate knowledge. Four fundamental purposes were identified in using games for these endeavors: games as a stimulus, intervention, incentive, and modeling. Stimulus games cause a measurable reaction or change in the player, while the research context is interested in monitoring and measuring that change. Intervention games intend to drive a long-term transformation in players for their benefit, as opposed to that of a researcher. Incentive games motivate participants to perform a particular task, the execution of which results in data collection. Finally, modeling games are used to model phenomena to study the resulting processes. The two academic games underlying this thesis — *CURIO*, a gamekit for teachers and students aimed at eliciting conceptual exploration, and *Shinobi Valley*, a game created to measure and study player behavior as it was influenced by level design — exemplify games as intervention and stimulus respectively.

In addition to fundamental purposes, three facets of academic games were established. These relate to information flow (i.e., how information is transferred between participants and researchers), dependency (i.e., how reliant the academic context is on the game artifact), and specificity (i.e., how specific a game's design needs to be to serve the academic purpose).

Awareness of these terms and making them explicit may help in planning and conducting academic research involving games as research tools. They support discussions and decisions in research projects, especially when multiple stakeholders work together. As the practical work in this thesis illustrates, exploring through games can be complicated and requires knowledge from various disciplines. The formulation of purposes for and facets of academic games aims to help practitioners make informed decisions and professionalize the ongoing practice of academic exploration through games.

9.1.6 Games Facilitating Exploration

The work presented in this thesis addresses the main research question it examines: *How do games facilitate exploration?*

The thesis answers this question by examining exploration *in and through* games from various perspectives. These perspectives were investigated through the sub-questions discussed above. In answer to the main research question, it is evident that exploration in video games occurs in various forms as the result of careful design. Conceptual, social, and spatial exploration were examined in closer detail. The thesis provides insight into how such exploration may be elicited purposefully through design patterns for exploration, purposeful and repeatable implementations of creative decisions meant to evoke different forms of curiosity, and their corresponding exploratory behavior. The thesis also presents a blueprint for how such patterns may be formed, implemented, and evaluated. In addition, the thesis identifies a new form of applied game, i.e., academic games: games used and developed within academic institutions for the generation, evaluation, or dissemination of knowledge.

By combining these perspectives, the thesis offers solid contributions (further discussed in the following section) to the existing literature and a foundation for future research efforts further examining exploration in and through games.

9.2 Contributions

This thesis contributes to the understanding of exploration in and through games. It examined a dominant motivator of exploration — the state of curiosity — and how it relates to games in various forms. The contributions of this work are both theoretical and practical. The theoretical contributions concern the creation of a corpus of games known to stimulate multiple forms of curiosity for future study. It also formulates the foundation for potential game design patterns that elicit certain forms of curiosity and concrete design patterns for spatial exploration. It presents a classification of games used for academic exploration and the facets that define them. The practical perspective lies in the presentation of two case studies. Together, these studies illustrate the practical aspects of designing and developing video games for exploration. The first focused on the general complexities in designing for conceptual exploration. The second showed how design patterns were implemented in a stimulus game for research and the design and execution of an empirical study to validate those patterns. This can form an example for the further study of design patterns for exploration.

In summary, the main contributions of this thesis are:

1. **The CURIO gamekit (Chapter 3):** The *CURIO* case study illustrates the intricacies of designing, in a most transparent manner, for conceptual curiosity and exploration. It shows the importance of balancing the player's knowledge gap, and its design may be used as a blueprint to create testing tools that can further examine this topic. *CURIO* may also be used as an example for other game-based learning projects, inspiring them to aim beyond testing prior knowledge and encourage learning through curiosity and exploration.

2. **A corpus of games for the further study of curiosity and exploration in games (Chapter 4):** Through the suggestions of survey participants, a list of 15 selected game titles was ranked by their potential to elicit curiosity. This selection was extended by participants' suggestions based on proposed game genres. The study found a selection of games that were particularly successful at stimulating curiosity in different ways, characterized by the genres of *Exploration*, *RPG*, *Puzzle*, *Social Sim*, and *Collecting*. Overall, the study's results provide evidence for the theory that games that strike a balance between uncertainty and structure tend to rank high. In contrast, highly deterministic games (requiring only cognitive or physical aptitude) or highly random tend to rank lower in curiosity. The list of games and genres provides a starting point for considering what game titles and genres should be analyzed regarding their potential to elicit curiosity.

3. **A well-defined set of strategies for conceptual, social, and spatial exploration (Chapter 5):** Through an analysis of games provided by participants and similar titles, strategies were formulated for how these types of games elicit conceptual, social, and spatial exploration. These strategies can form the based for the formulation of design patterns for games that stimulate these types of exploration. Five design patterns for spatial exploration were devised through an analysis of games and existing game design patterns.

4. **A blueprint of a research game for the empirical study of design patterns for exploration and well-defined models of measures and their analysis (Chapters 6 and 7):** Design patterns for spatial exploration were implemented into a research game and validated in an empirical study. The study provides a pioneering quantitative assessment of design patterns. It shows the complexities of ex-

ploratory behavior and how it is influenced by the presence of patterns, an in-game goal, and other factors. Additionally, the study design serves as a blueprint for future studies with similar aims.

5. **A classification of games for academic exploration (Chapter 8):** A definition was presented for “academic games”, a sub-field of applied games that is shaped by a purpose and the involvement of stakeholders from research and education institutions. Four fundamental purposes for academic games were identified: stimulus, intervention, incentive, and model. Facets of game involvement were furthermore defined based on how games interface with the academic context they are in: information flow, dependency, and specificity. The formulation of these purposes and facets can help professionalize the practice of “exploration through games” and provides a basis for a future research agenda.

This thesis combined disciplines and knowledge from various fields, including philosophy, psychology, applied games, game-based learning, game user research, and game design. It provides a comprehensive overview of exploration in and through games, making it relevant to academics that include games in their practice. This is also reflected in the venues in which separate papers have been published (e.g., multidisciplinary conferences) and the levels at which implementations have been tested and disseminated: schools in Malta and the Netherlands and academic circles in different disciplines.

9.3 Future Work

This thesis contributes to the budding field of curiosity and exploration in games. Although it is a topic that is implicitly discussed and understood to be important, it has seen relatively little formal and empirical study. Similarly, games are increasingly often used in research and educational contexts, even as they are not fully understood. Although many individual studies have come before, this work presents a necessary bridging of perspectives and suggests a way forward toward a more professionalized practice. Based on the insights of this research, the following directions can be considered for future studies:

- **Further study the corpus of games:** The thesis presented a start for the further study of games and game genres and how they elicit exploration. This, however, is only the beginning. The corpus of games can form the start for further explorations, analyzing the games on the list and using them as a starting point for gathering similar titles through which the notions of curiosity and exploratory behavior can be better understood. Obvious directions are conceptual and social exploration, as the two genres are considered most successful at eliciting curiosity besides spatial exploration. However, other types of games may also be analyzed further.
- **Formulate, implement, and validate design patterns for exploration:** The thesis formulated five design patterns for spatial exploration, implementing and validating four of those patterns through an empirical study. These were formulated as a step toward empirical research that can assess the efficacy of hypothesized patterns. Their formulation and implementation into stimulus games, as well as the detailed description of research considerations and study design, can serve as a blueprint for further studies. Many more design patterns for the various forms of exploration discussed in this thesis may be formulated. Their empirical study can not only result in generalizable design knowledge but also further help understand player psychology and behavior.
- **Professionalize the practice of academic exploration through games:** This thesis formed a foundation for a research agenda regarding the use of games in academic contexts. Starting from the proposed classification of purposes and facets, prior work on applied games and game design could further be examined on whether it requires specialization to fit the academic context better. Further study could also involve how different academic fields approach the involvement of games for research purposes, e.g., strategic review of (individual case studies). The mapping of stakeholders often involved in the use and creation of academic games could help to understand the various forces that shape the practice of academic exploration through games, e.g., in regard to expectations depending on professional background and their influence on decision-making. This could lead to the formulation of design guidelines, frameworks, and toolkits aimed at the creation of academic games.

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Acronyms

5DC Five-Dimensional Curiosity Scale. 20, 21, 22, 57, 66, 67, 70, 74, 77, 78, 84, 85, 86, 88, 97, 173, 184, 194, 225

eSFQ Extended Short Feedback Questionnaire. 46, 48, 49

GBL Game-Based Learning. 15, 16, 25, 26, 29, 36, 52, 54, 55, 201

GUESS Game User Experience Satisfaction Scale. 173, 177, 184, 185, 187, 194, 197

GUR Game User Research. 5, 205

OSF Open Science Framework. 119, 175, 180

PIR Pattern Instantiation Region. 125, 140, 141, 147, 152, 153, 154, 176, 181, 182, 183, 184, 186, 188, 189, 191, 192, 193

STEM Science, Technology, Engineering, and Mathematics. 23, 25, 27, 31

PhD Manuscript — 2023

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