T.C.
BAHCESEHIR UNIVERSITY
GRADUATE SCHOOL
THE DEPARTMENT OF GAME DESIGN
MASTER'S PROGRAM IN GAME DESIGN

SOCIAL CORRELATES OF IMMERSION IN EVE ONLINE

MASTER'S THESIS

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GRADUATE SCHOOL

26/05/2025

MASTER THESIS APPROVAL FORM

Program Name:	Game Design
Student's Name and Surname:	Nazım Adaklı
Name Of The Thesis:	Social Correlates of Immersion in Eve Online
Thesis Defense Date	26.05.2025

This thesis has been approved by the Graduate School which has fulfilled the necessary conditions as Master thesis.

Assoc. Prof. Yücel Batu SALMAN

Director of Graduate School

This thesis was read by us, quality and content as a Master's thesis has been seen and accepted as sufficient.

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ABSTRACT

SOCIAL CORRELATES OF IMMERSION IN EVE ONLINE

Adaklı, Nazım

Game Design Master's Program

Thesis Advisor: Assoc. Prof. Diğdem Sezen

May 2025, 61 pages

This thesis investigates immersion in digital games by critiquing prevailing sensory-motor and attention-based models. Utilizing Eve Online as a case study, the research combines philosophical critique, empirical research, and game design analysis. A quantitative survey comparing large-scale battles and small engagements reveals that attentional and sensori-motor factors do not exhaust the immersive experience. The findings suggest that social factors might be driving immersion in certain cases in Eve Online, challenging conventional theories and offering insights to game designers aiming to create compelling virtual worlds through enriched social dynamics.

Keywords: Immersion, Game Design, Eve Online

ÖZET

SARMALANMANIN EVE ONLINE'DAKİ SOSYAL BELİRLEYİCİLERİ

Adaklı, Nazım

Oyun Tasarımı Yüksek Lisans Programı

Tez Danışmanı: Doç. Dr. Diğdem Sezen

May 2025, 61 sayfa

Bu tez, dijital oyunlardaki sarmalanma deneyimini hakim duyusal-motor ve dikkat temelli modelleri eleştirerek incelemektedir. Çalışma Eve Online'daki oyuncu deneyimlerini örnek vaka olarak kullanarak, felsefi eleştiri, ampirik araştırma ve oyun tasarımı analizini bir araya getiren bir metodoloji içermektedir. Oyun içineki büyük ölçekli savaşlarla küçük çatışmaları kıyaslayan nicel bir anket, dikkat ve duyusal-motor faktörlerinin sarmalanma deneyimini tam anlamıyla açıklamadığını ortaya koymuştur. Bulgular, Eve Online'da belirli durumlarda sosyal faktörlerin sarmalanmayı yönlendirmiş olabileceğini öne sürerek geleneksel teorilere meydan okumakta ve zenginleştirilmiş sosyal dinamiklerle etkileyici sanal dünyalar tasarlamayı amaçlayan oyun tasarımcılarına değerli içgörüler sunmaktadır.

Anahtar Kelimeler: Sarmalanma, Oyun Tasarımı, Eve Online

To Ayla, my beautiful wife, without whom this thesis would not be possible.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my thesis advisor, Assoc. Prof. Dr. Diğdem Sezen, for her invaluable support and inspiration. Her expertise and encouragement were crucial to the completion of this thesis.

I am deeply grateful to Dr. Güven Çatak, Head of the Game Design Department at Bahçeşehir University, for believing in my potential and providing me with numerous opportunities.

Lastly, I wish to extend heartfelt thanks to Assistant Prof. Zac Irving from the Department of Philosophy at the University of Virginia. His unwavering guidance, mentorship, and intellectual inspiration have profoundly influenced my academic growth over the past six years.

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Chapter 1

Introduction

1.1 Theoretical Framework

Immersion in games is a complex concept studied across many disciplines. This thesis adopts a multi-methodological framework to tackle the conceptual confusion surrounding the concept of immersion in academic, industrial and cultural circles. In particular, the literature review is approached as a philosophical critique rather than a standard summary. Philosophical inquiry is employed to clarify concepts and interrogate assumptions, which is crucial because empirical findings alone have not resolved core definitional questions. Philosophical engagement with immersion has been scarce in past research, yet it is warranted when different fields use the term inconsistently. By using careful logical interrogation and thought experiments, this thesis aims to untangle conceptual contradictions in the immersion discourse. In addition to the philosophical approach, a psychological methodology is integrated to empirically test the new ideas developed. An online survey study with Eve Online players provides quantitative data, allowing the thesis to validate its theoretical claims about immersion's social dimensions in practice. Finally, a communicational (game design) perspective underpins the research, ensuring that the analysis remains grounded in how immersion is understood and crafted within game design and player communities. In sum, the theoretical framework combines philosophical analysis, psychological experimentation, and game design insights to examine immersion from multiple angles.

1.2 Statement of the Problem

Both academic literature and industry practice have so far relied on insufficient analyses of immersion. Immersion is commonly described as the experience of "being in a different world," yet there is no consensus on how this experience is induced by media. Two dominant models pervade current thinking; sensori-motor and attention-based interpretations. The sensori-motor model (rooted in virtual reality research) equates immersion with the envelopment of the senses through technology, while the attention-based model associates immersion with a group terms of such as involvement, engagement, engrossment, cognitive absorption, focus, or flow. As each of these concepts are closely related to attention, I call this interpretation as the attention-based model.

Each model captures only part of the phenomenon. Relying on these frameworks do not fully do justice to the rich "being in a different world" experience that players and designers associate with immersion. Notably, both models have largely overlooked social factors, treating immersion as a solely individual sensory or attentional state. This has created a gap between what players find immersive in games and what scholars measure; for example, widely used questionnaires on presence and immersion devote only token attention to social presence or world believability. The result is an analytical blind spot. Aspects like community, story, and social interaction are undervalued in formal theory and metrics.

These conceptual issues have practical repercussions in game development. In the industry, a narrow focus on sensori-motor immersion has encouraged an arms race for photorealistic graphics and virtual reality hardware under the assumption that better

sensory envelopment equals more immersion. Major studios have poured hundreds of millions of dollars into state-of-the-art audiovisual fidelity, only to find that lavish visuals alone do not guarantee an absorbing experience. Over-investment in the sensori-motor paradigm has at times led to disappointing outcomes (such as the slower-than-expected adoption of VR gaming) when other immersion factors were neglected. Meanwhile, attention-based models, which overlap heavily with the concept of flow, have not remedied the situation. Treating immersion as nothing more than focused attention risks diluting the concept. In short, the problem driving this research is that current models of immersion are too limited. They omit social-contextual dimensions and thus fail to fully explain or reliably produce the profound sense of being in an alternate world. This thesis addresses that problem by critically examining those models and proposing an expanded view centered on social correlates of immersion.

1.3 Purpose of the Study

The purpose of this study is to investigate the nature of immersion in digital games through a new lens that foregrounds its social dimensions. By using Eve Online, a massively multiplayer online game with rich player interactions, as a case study, the research aims to challenge the prevailing sensorimotor and attention-based accounts of immersion and explore how social factors contribute to the feeling of "being in a different world." Ultimately, the study seeks to develop and empirically support a socially-focused theory of immersion that better accounts for aspects of player experience often overlooked in traditional models. This entails formulating a theoretical framework that integrates social context into the concept of immersion and testing this framework to demonstrate its explanatory power in a real game setting.

1.4 Research Questions

This research is guided by the two following questions;

1) Is the immersive experience exhausted by sensori-motor and attentional factors?
2) Do social factors have an influence in the immersive experience?

These questions direct the inquiry beyond the individual player's sensory inputs or attention span, instead evaluating immersion through a novel lens that includes multiplayer dynamics, narrative engagement, and community presence. By framing immersion in terms of social influence, the study examines whether elements like collaboration, competition, in-game culture, and communication among players significantly affect the depth of the immersive experience. Investigating this question involves both a critical theoretical analysis of immersion concepts and an empirical evaluation within Eve Online, thus linking abstract theory with observable player experiences. The answer will illuminate how much social factors matter relative to the traditional technical factors, thereby testing the proposed socially-oriented perspective on immersion.

1.5 Significance of the Study

Clarifying and reframing the concept of immersion carries high stakes both for theory and practice. Theoretically, this study addresses a long-standing conceptual muddle in the academic discourse. By dissecting immersion's contributing factors and highlighting the role of social factors, the thesis contributes to a more robust understanding of an experience that, until now, has been only partially explained. It

challenges researchers and game designers to look beyond sensory hardware or individual cognition and consider the situated, social aspects of immersive play.

Practically, immersion is a driving goal in a multi-billion-dollar game industry, making this research exceedingly relevant. Games and virtual reality experiences are marketed on their immersiveness, and developers invest enormous resources in pursuit of deeper player engagement. Misconceptions about what truly creates immersion can lead to costly misallocations of effort: for example, over-prioritizing graphics technology at the expense of gameplay or social features has resulted in beautiful but shallow products. By shedding light on social correlates of immersion, this study offers insights that can help game designers and industry stakeholders make more informed decisions. If social interactions and world building are affirmed as critical to immersion, design practices and funding priorities can shift to cultivate these elements. In sum, the significance of this work lies in advancing scholarly understanding of immersion while also providing guidance to an industry eager to craft compelling virtual worlds. A better grasp of immersion's full nature —including its social core—stands to benefit player experience, guide design innovation, and prevent the kinds of missteps that occur when an incomplete theory of immersion drives development.

1.6 Definitions

For the purposes of this thesis, several key concepts are defined as follows:

Presence: The experience of being there.

Basic Immersion (BI): The experience of being in a different world. This refers to the fundamental feeling of entering an alternate reality or environment, as reported by the participant.

Sensori-Motor Factors (SMF): Factors contributing to the immersive experience via envelopment of the participant's sensori-motor faculties by technological devices. In this interpretation, immersion arises by enveloping participant's sensory inputs and motor feedback (e.g., through virtual reality equipment) so that the virtual world dominates their perception.

Attention-Based Factors (ABF): Factors contributing to the immersive experience via the absorption of the participant's attentional resources by the virtual environment. In this framework, immersion is associated with a group of concepts closely related to attention; including involvement, engagement, engrossment, cognitive absorption, focus, or flow.

Chapter 2

Literature Review and Critique

2.1 Pre-Theoretical Immersion as Being in a Diferent World

The concept of immersion is rooted in the notion of presence, initially engaged primarily by virtual reality (VR) researchers during the 1990s. The term "telepresence" first appeared as a fictional concept in Robert A. Heinlein's novels (1942), significantly predating the white paper on the first VR headset by Sutherland (1968). Later, Minsky (1980) repurposed the concept of presence within the context of teleoperation, more commonly recognized today as remote-control technology involving devices such as drones operated via cameras and screens. In this context, presence referred to providing a remote participant with a sense of "being there," in another physical location. Notably, even standard audiovisual outputs such as a screen and speaker were sufficient, according to Minsky, to induce the experience of "being there." A philosophical precursor to Minsky's conceptualization can be found in Daniel Dennett's article "Where Am I?", in which Dennett argues that a person's identity does not reside wherever their brain or body is physically located, but rather wherever their subjective point of view exists. Dennett employs several examples of teleoperation to illustrate how participants undergo significant shifts in their subjective point of view.

In the 1990s, both military and commercial interests propelled industrial and academic research in virtual reality (VR). The term presence was adopted to describe the sensation of "being there" within VR experiences (Reeves, 1991; Heeter, 1992). Heeter (1992, p. 4) also mentions "immersion VR," referring to technology that combined head-mounted displays with movement trackers capable of detecting a

participant's bodily motions. In such a system, the headset displays a virtual world, within which a virtual avatar replicates the participant's tracked movements, thereby creating a sense of being present in the virtual environment. This configuration remains the most common VR setup today, although current movement trackers are typically integrated within the headset itself rather than being positioned externally. At the time, alternative VR configurations also existed. For instance, Heeter (1992) described a "second-person VR," which involved aiming a camera at participants placed against a green-screen background. Participants would then view themselves within a computer-generated virtual environment on a large external screen. Thus, Heeter's initial use of the term immersion specifically distinguished the headset-based VR setups—now the dominant form—from other experimental VR configurations, highlighting the unique, vision-enveloping capabilities of the headset-based systems.

As headset-based setups became dominant in early VR research, researchers gradually started replacing the term presence with immersion. This shift is evident in *Presence*, the leading journal for VR research at the time, where scholars began to use "immersion" interchangeably with "presence" (Heim, 1994; Larjani, 1994; Wloka, 1995; Coomans & Timmermans, 1997; Pausch, 1997; Flach & Holden, 1998; Chance et al., 1998; Witmer & Singer, 1998; Joris & Werkhoven, 1998; Bystrom et al., 1999). The change in terminology likely occurred because headset-based VR configurations had become the prevailing standard. Another contributing factor may have been the absence of an adjective form for "presence," in contrast to "immersive." Drawing on the early VR literature reviewed above, immersion can be distilled into the following definition.

Presence: The experience of being there.

Some early researchers distinguished immersion from presence. According to Witmer and Singer (1998), immersion was one of two necessary conditions for presence, with involvement as the other. This perspective anticipated the two dominant interpretative branches of immersion in contemporary research. Similarly, Slater et al. (1998) viewed the concept of immersion as referring to a lower degree of presence. Common to both perspectives is the idea that immersion can vary in degree, whereas presence remains a binary concept. An implication of this understanding is that immersion is measurable by degrees and can thus be experienced outside VR environment, albeit to a lesser extent. This was an interpretation that influenced subsequent research.

Presence is overly broad relative to how most stakeholders conceptualize immersion. Consider, for example, a participant using a VR headset that places them in a blank, featureless space. According to many early and most contemporary accounts, this scenario does not qualify as an immersive experience. Both VR and teleoperation contexts inherently presuppose positioning the participant within a tangible, believable location or environment. Thus, researchers began to qualify the virtual environment in which immersion occurs.

Indeed, from early research onward, analyses of immersion frequently emphasize the concept of entering "a different world," rather than merely occupying a distinct physical location. For instance, Heeter defines presence as "feeling like you exist within but as a separate entity from a virtual world that also exists" (1992, p. 3). The emphasis on the "different world" theme became increasingly prominent as the research context shifted from teleoperation to VR, and subsequently to non-VR media. Murray (1998) describes immersion as "the sensation of being surrounded by a

completely other reality." McMahan (2003) argues that immersion involves the player becoming caught up "in the world of the game's story." Wirth et al. (2007) define immersion as "a game's capacity to produce the feeling of actually being part of, or present within, the game environment." Similarly, Kiili et al. (2012) describe immersion as "a sensation of being surrounded by a completely other reality." Virtually all contemporary immersion research explicitly references a virtual world, either within the definition itself or throughout their analyses. Researchers employ varied phrasing preferences, for example, "feeling" versus "experience," "existing" versus "being," and "environment," "universe," or "reality" versus "world." Since no substantial analytic differences exist among these terminological choices, I group these interpretations under the following unified definition.

Basic Immersion (BI): The experience of being in a different world.

BI is prevalent not only within academic research but also in informal discussions surrounding immersion. ARM, a British semiconductor company specializing in immersive hardware, defines immersive games as "video games that transport the player into an alternative world" ("What is Immersive Gaming?"). Bryan Wirtz (2023), a game design educator, suggests that "video game immersion brings you out of the real world and transports you and your brain into a different reality." Quantic Foundry, a company specializing in player motivation psychology, defines immersive games as "games with interesting narratives, characters, and settings so players can be deeply immersed in the alternate worlds created by games" ("Gamer Motivation Profile"). Similarly, an anonymous blog post on the University of Silicon Valley website proposes that "the easiest way to achieve a strong level of immersion is to make the game world as believable as possible" ("How to Make Immersive Game Design,"

2023). Evidently, for most formal and informal stakeholders, presence is insufficient to fully characterize the immersive experience. The more elaborate concept of a world is necessary to adequately capture immersion.

I think it is safe to assume that virtually all researchers and commentators of immersion agree with the BI definition. Therefore, BI will serve as an anchor point throughout this thesis, a concept we repeatedly turn back to and attempt to make sense its psychological contributors.

While BI is generally acceptable to most stakeholders, analytical disagreement arises regarding how this immersive experience occurs, and the ways it can be induced or replicated. Broadly, and setting aside finer nuances for clarity, these analytical approaches can be categorized into two dominant perspectives within the literature:

Sensori-Motor Factors (SMF): Factors contributing to the immersive experience via envelopment of the participant's sensori-motor faculties by technological devices. In this interpretation, immersion is associated by the envelopment of participant's sensory inputs and motor feedback (e.g., through virtual reality equipment) so that the virtual world dominates their perception.

Attention-Based Factors (ABF): Factors contributing to the immersive experience via the absorption of the participant's attentional resources by the virtual environment. In this framework, immersion is associated with a group of concepts closely related to attention; including involvement, engagement, engrossment, cognitive absorption, focus, or flow.

Historically, there has been two main interpretations of immersion that either emphasized SMF or ABF. Analytically, disputes between these two perspectives

manifested in various forms. A complete rejection of one definition by proponents of the other is uncommon. Most of the VR-related research covered in section 2.2 implicitly prioritizes sensori-motor factors without entirely dismissing alternative pathways to immersion. Conversely, another form of analytical disagreement involves explicitly emphasizing attentional factors over sensori-motor factors, a stance prevalent among researchers whose work I will discuss in section 2.3.

The immersion literature has predominantly centered around sensori-motor and attention-based factors, each providing a robust yet somewhat compartmentalized understanding of immersive experiences. While these two perspectives have significantly contributed to our understanding, I remain skeptical that they comprehensively exhaust the multidimensional nature of immersion. Given the complexity of human cognition and social interaction, it seems plausible that other dimensions, particularly those related to social dynamics, may also meaningfully contribute to immersion. Thus, exploring immersion through these alternative lenses may offer a richer and more nuanced conceptualization beyond the current dominant frameworks. Thus, I will introduce the theoretical background for social factors contributing to immersion in the section 2.4.

2.2 Sensori-Motor Factors

The emphasis of Sensori-Motor Factors (SMF) emerged from early VR literature, which primarily focused on the notion of presence and emphasized the sensory envelopment (particularly visual) afforded by VR devices. A clear formulation of this interpretation can be found in Witmer and Singer (1998). They define immersion as "a

psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences." Furthermore, they define presence as "the subjective experience of being in one place or environment, even when one is physically situated in another." Witmer and Singer posit immersion and involvement as the two necessary conditions for presence. According to this framework, when an individual is sensorily enveloped by an environment and simultaneously attentive to its stimuli, the result is the experience of presence in a different environment.

Many other early VR researchers treated immersion directly as presence or as a closely related sensori-motor concept (Heim, 1994; Larjani, 1994; Wloka, 1995; Coomans & Timmermans, 1997; Pausch, 1997; Flach & Holden, 1998; Chance et al., 1998; Witmer & Singer, 1998; Joris & Werkhoven, 1998; Bystrom et al., 1999). Given that VR constitutes a human experience, psychological research on VR-based immersion and presence followed technological advancements in computer science. This psychological research linked VR experiences to empirical metrics, including self-reports, observable behaviors, and neurological correlates, and relied extensively on the concept of presence and its associated terminology. For example, Wiederhold et al. (1998) found that VR experiences exhibited a stronger correlation with skin conductivity than traditional screen-based experiences. Sallnäs (1999) demonstrated that incorporating haptic feedback during VR sessions further increased the sense of presence. Researchers also examined behavioral metrics associated with presence, such as vection, the behavioral correlate of the feeling of self-motion (Ohmi, 1998; Prothero, 1998); as well as postural movements (Freeman et al., 2000) and body and eye movements (Cairns et al., 2006).

From a neuroscientific perspective, research investigating neural correlates of presence has consistently identified the frontoparietal connections in the brain as closely associated with presence (Baumgartner et al., 2006; Jäncke et al., 2009; Kober et al., 2012; Clemente et al., 2013). Jäncke et al. (2009) suggest that the correlation between this brain region and presence arises because this region governs motor simulations derived from an internally represented spatial model of one's surroundings. In simpler terms, the brain region responsible for simulating (but not executing) motor movements was found to be essential for experiencing presence. In related research, Baumgartner et al. (2006; 2008) provided neurological evidence linking presence to the temporoparietal junction, a brain area also implicated in out-of-body experiences. This finding supported earlier theoretical propositions categorizing presence as an out-of-body phenomenon (Rheingold, 1991; Sanchez-Vives & Slater, 2005). Furthermore, the strong association of the parietal lobe with presence underscored the conceptual closeness between identity and presence. For instance, experiences in non-VR role-playing games utilizing a third-person camera perspective resulted in heightened activity in the left parietal lobe, a region involved in self-identification from a third-person viewpoint (Ganesh et al., 2011). Collectively, neuropsychological research grounded the concepts of presence and immersion in neural correlates linked to existing in, modeling, and simulating motor movements within a given space. Such studies emphasized the visceral, unconscious, and non-deliberate connections established between the participant and the virtual world.

This sensory-first approach to immersion dominated the early VR literature and subsequently exerted considerable influence on later non-VR interpretations of the concept. Questionnaires used in research primarily emphasized sensory dimensions.

Neuropsychological studies aimed to identify neural correlates that differentiated VR experiences from their non-VR counterparts. Computer science research concentrated on enhancing VR systems by expanding the visual field provided by headsets, improving the audiovisual quality of both hardware and the software that generates continuous sensory stimuli, and advancing interactivity through controllers (e.g., Meta Quest), body tracking (e.g., Apple Vision), and tactile feedback technologies. Collectively, this sensory-oriented perspective on immersion forms the conceptual basis for what I refer to as sensori-motor interpretation of immersion.

The most common stance within the sensori-motor interpretation holds that sensori-motor factors are necessary for inducing immersion. This position was maintained, either implicitly or explicitly, by VR researchers throughout the 1990s. While explicitly illustrated by Witmer and Singer's Presence Questionnaire (1998), nearly all early VR research published in *Presence* presumed that the sensori-motor envelopment provided by VR devices is an indispensable element of immersion. Some early VR scholars adopted an even stronger position, arguing that sensori-motor are both necessary and sufficient for immersion. This viewpoint is typically defended on semantic grounds. Advocates do not necessarily claim that sensori-motor envelopment is the exclusive method of causing someone to experience being in a different world. Rather, they contend that the concept of immersion should strictly apply only to the experience of being in a different world as induced by sensory-motor factors. For example, Slater (2003) defends this position as follows:

> Let’s reserve the term “immersion” to stand simply for what the technology delivers from an objective point of view. The more the system delivers displays (in all sensory modalities) and tracking that preserves fidelity in relation to their equivalent real-world sensory modalities, the more that is immersive.

Similarly, Bostan (2022) argues for a conceptual distinction between immersion and presence, proposing that "immersion" should specifically denote the experience of sensory envelopment by technological devices, while "presence" should denote the subjective experience of "being there," aligning with the approach of Witmer and Singer (1998). Bostan argues that these definitions more accurately reflect the original conceptualizations of immersion and presence.

I disagree with this semantic argument based on the concept's historical origins. While it is true that Heeter (1992) and other very early VR researchers employed the term "immersive VR" specifically within contexts involving sensori-motor envelopment, they also analyzed the psychological dimensions of these experiences, labeling them as presence. As discussed in section 2.1, researchers did not limit themselves to the immediate sensory experience of "being there". Rather, their analyses extended to include the experience of "being in a different world." Furthermore, it was precisely these early VR scholars who gradually phased out the term "presence" in favor of "immersion," after which the concept was appropriated by researchers in non-VR contexts. Admittedly, early VR researchers were not explicitly concerned with broader, non-VR modalities of immersive experiences. However, this does not imply that alternative modalities are incapable of inducing the very experience those researchers initially investigated. Early VR researchers shared the BI definition with the wider immersion discourse. Therefore, contrary to Slater (2003) and Bostan (2022), I argue that the original development of the concept does not exclusively justify the SMF based interpretation.

Moreover, any stance asserting that SMF are necessary for immersion inherently excludes non-sensory modalities of immersive experience. For instance,

such a position implies that tabletop role-playing games (RPGs), such as sessions of Dungeons and Dragons, cannot qualify as immersive because they lack the (audiovisual) sensory stimuli required to envelop the participant. Tabletop RPGs primarily unfold through verbal communication rather than through sensory stimuli from screens or similar technologies. Generalizing from this example, this interpretation similarly excludes numerous non-sensory contexts where the game world or narrative is communicated verbally. Beyond tabletop games, this exclusion extends to books, fables, legends, and other media that rely predominantly on verbal rather than sensory means of communication, thus disqualifying them from being immersive according to this interpretation.

Many stakeholders would disagree with such an exclusion. Academics, industry professionals, and game critics alike seek to include non-sensory modalities in their analyses of immersion. As immersion research shifted away from early VR technologies toward PC gaming, researchers increasingly emphasized non-sensory modalities. With the growing understanding of immersion's relationship to attention, involvement, and engagement, subjective experiences became the primary focus, rather than sensory envelopment. Both contemporary academic research and non-academic discourse have moved beyond excluding non-sensory forms of immersion. Nearly all modern research incorporates non-sensory immersion modalities. Examples of research that conceptualize and categorize non-sensory immersion modalities include diegetic immersion (McMahan, 2003), mental immersion (Sherman, 2003), cognitive and emotional immersion (Björk & Holopainen, 2004), challenge-based and imaginative immersion (Ermi & Mäyrä, 2005), fictional and systemic immersion (Arsenault, 2005), psychological immersion (Carr et al., 2006; Agrawal et al., 2020), ludic, narrative, and

social immersion (Thon, 2008), narrative, strategic, and tactical immersion (Adams, 2014), and empathetic immersion (Zhang et al., 2017). Even contemporary VR-oriented research explicitly refers to the experience of being physically situated in another world as "physical immersion" (Sherman & Craig, 2018), clearly implying the existence of additional forms of immersion.

The experience of being in a different world is inherently interesting for all stakeholders, and potentially even more worthy of research than the sensori-motor factors themselves. Restricting the concept of immersion solely under the sensory-motor interpretation unnecessarily sacrifices the explanatory power of a broader conception. The benefit of conceptual clarity through semantic conservatism should not outweigh the value gained by encompassing all forms and modalities of the experience of being in a different world. Therefore, I conclude that there can be instances of immersive experience in which sensori-motor factors are not the primary drivers. As discussed, sensori-motor factors have been foundational to immersion research. Yet, as I argued, if we want to accept that a tabletop Dungeons and Dragons game can be immersive, then we would have to accept that it is possible to achieve immersion without live sensori-motor stimulation.

There is still the inverse question of whether sensori-motor stimulation alone is sufficient for immersion. As discussed in previous sections, immersion is often considered as a concept that comes in degrees, and sensori-motor envelopment constitutes an ever-moving target. Experiences in contemporary VR setups are labeled as immersive today, yet even teleoperation via screens was similarly considered immersive in the 1960s. While increased envelopment likely correlates positively with immersion, it may not guarantee immersive experiences on its own. To address whether

sensori-motor factors alone always suffice, it is preferable to examine scenarios that provide extensive sensori-motor stimulation but nevertheless fail to elicit sustained or meaningful immersion.

As a thought experiment, consider a scenario inspired by the Matrix trilogy, where an individual is connected to a hypothetical neural interface device capable of perfectly stimulating all senses. Imagine this person placed within a completely featureless virtual room; empty, monochrome, and devoid of any distinguishable content or interactive possibilities. Despite total sensori-motor envelopment, I do not think this scenario would result in an immersive experience. If BI is the experience of being in another world, one cannot say that this person is having that experience

To explore this further, one might posit a composite theory of immersion, suggesting that sensori-motor envelopment alone might not suffice without concurrent attentional engagement. Is it perhaps the lack of attention-worthy features that is leading to a lack of immersion? If the environment were instead furnished with items or interactive elements capable of capturing the participant's attention, would immersion then reliably occur?

Let us complicate the scenario further. Suppose the individual knows explicitly that this virtual room is all there is to the simulated reality; there is no world beyond its boundaries, no greater context or narrative. In such a scenario, despite possessing both complete sensory stimulation and elements demanding attention, it is doubtful that the participant would genuinely experience immersion in the sense of "being in a different world." Rather, the person might merely feel trapped in an artificial or sterile simulation, awareness of the inherent artificiality dominating their experiential frame.

Now, contrast this situation with another slight variation. Suppose the participant does not know they are within a virtual environment. Instead, they believe themselves to be simply locked within a physical room in the real world. In this scenario, it seems intuitively more plausible that they would experience genuine immersion, an authentic sense of existing within -a- reality. Even if that reality is as minimalistic as the featureless room, they would still feel like being in a (different) world. Here, the immersion seems driven significantly by their cognitive and epistemological framing rather than solely by sensori-motor or attentional factors.

This thought experiment raises a crucial critique of classical immersion theories, which often restrict themselves either to sensori-motor stimulation provided by the immediate surroundings or to the attentional engagement and cognitive absorption elicited by interaction with these surroundings. However, the belief that there exists a larger, continuous world beyond the immediate sensory frame seems crucially relevant. The awareness (or lack thereof) about the existence of a larger reality beyond the immediate surroundings emerges as a significant, perhaps indispensable, factor influencing whether a person experiences "being in a different world." Such insights indicate that current theoretical frameworks, dominated by sensori-motor and attention-based models, might not fully capture the nuances of immersion.

This thought experiment hints at a broader conceptual issue, highlighting two distinguishable but interrelated components of BI, “the experience of being in a different world.” The first component is phenomenological; it involves the subjective sensation of being present within a place. This is what is often termed "presence" in the literature. The second component, however, concerns belief. Specifically, the belief that the place one occupies constitutes an authentic, independently existing world. In my

opinion both the sensori-motor and attentional interpretations have disproportionately emphasized the aspect of presence, neglecting the equally important dimension of authenticity. As I shall elaborate in chapter 3 and subsequent discussions, the belief in an authentic world likely requires more than simply attending to sensori-motor stimulation or maintaining attentional engagement. Crucially, it may depend significantly on social factors and collective interactions, suggesting that social dynamics play an indispensable role in generating sustained, meaningful immersion.

So far, I have argued that the sensori-motor interpretation of immersion is inadequate in exhaustively explaining immersion. It is important to note that this is negatively influencing the game industry. Since the early 2000s, an industry-wide pursuit of photorealism driven by improvements in the sensori-motor factors has increased costs and prioritized visual fidelity over gameplay depth, narrative quality, and innovation. High-budget, visually sophisticated games have frequently lacked substantial ludic or narrative substance, leading to criticisms of style over substance. Furthermore, excessive reliance on photorealism can limit artistic creativity, narrow development priorities, and hinder smaller developers due to prohibitive costs. A prominent example of explicit sensori-motor commitment is the space MMO project Star Citizen, whose intense focus on visual realism led to persistent developmental and networking challenges, preventing successful launch despite massive funding. Similarly, industry-wide expectations of VR adoption based on SMF resulted in overly optimistic investments, ignoring inherent user-experience barriers like motion sickness, content scarcity, and cumbersome hardware. Broader concepts like the Metaverse also faltered by emphasizing sensory fidelity without meaningful interaction or social engagement. Overall, the industry's continued adherence to SMF-based immersion

remains problematic, and alternative attention-focused approaches have not adequately addressed these underlying issues.

2.3 Attention-Based Factors

In the early 2000s, research into immersion expanded beyond virtual reality, marking a second frontier within the domain of video games. This shift coincided with a period often considered the golden age of PC gaming, characterized by increasingly powerful and impactful audiovisual experiences. Interest in immersion broadened significantly within both academia and the games industry, leading to a diversification of perspectives on the concept. Scholars began to recognize that psychological states associated with immersion or presence under the SMF interpretation framework could also occur without VR. This recognition prompted researchers to theorize deeper forms of connection between participants and virtual worlds beyond the visceral, unconscious, or purely sensory domains of cognition. It became evident that even non-digital experiences, such as tabletop role-playing sessions like Dungeons & Dragons, could evoke the experience of "being in another world." Consequently, the SMF framework and existing empirical research on presence proved inadequate for explaining immersion in contexts where sensory envelopment is minimal or entirely absent.

Three analytical clusters have emerged to explain non-sensory immersion, with the primary one being what I term the attention cluster. One such cluster focuses on narrative, story, and fiction within games. Categories within this cluster include imaginative immersion (Ermi & Mäyrä, 2005), fictional immersion (Arsenault, 2005), and narrative immersion (Thon, 2008; Adams, 2014). This line of inquiry largely originates from Ermi and Mäyrä's (2005) concept of imaginative immersion, described

as absorption into a game's narrative or fictional world. However, subsequent analyses within this narrative-focused cluster primarily rely on cognitive absorption, which I categorize within the attention cluster. Consequently, narrative based interpretations of immersion are effectively a subset of the attention cluster and does not warrant separate analysis, as fiction and narrative are argued to achieve immersion predominantly through cognitive absorption mechanisms.

Another analytical cluster has focused on non-sensory dimensions of human cognition. This includes psychological immersion (McMahan, 2003; Carr et al., 2006; Agrawal et al., 2020; Chalmers, 2022), cognitive and emotional immersion (Björk & Holopainen, 2004), empathetic immersion (Zhang et al., 2017), and mental immersion (Sherman & Craig, 2018). A key issue in this cluster is the problematic dichotomy established between sensory-motor and so-called “psychological” or “mental” aspects of cognition. The frequent categorization contrasting perceptual immersion with psychological immersion overlooks that perception itself is inherently psychological. Furthermore, analyses within this cluster also largely reduce immersion to attention-based phenomena. For instance, psychological immersion is defined as mental absorption (McMahan, 2003), mental immersion as deep engagement (Sherman & Craig, 2018), cognitive immersion as abstract reasoning and focused attention (Björk & Holopainen, 2004), and emotional or empathetic immersion as emotional involvement (Björk & Holopainen, 2004; Zhang et al., 2017). Therefore, this cluster, too, effectively falls under the broader attention cluster due to its reliance on attention-related cognitive processes.

The primary insight gained from these two clusters is that immersion can arise from non-sensory means, such as through narrative or verbal communication, engaging

cognitive processes beyond mere perception. Nevertheless, since both clusters fundamentally rely on attention-related concepts, their analyses align closely with the attention-based interpretation of immersion. The divergence occurs primarily because these perspectives shift the analytical focus away from attention itself, emphasizing instead either the objects of attention (e.g., narrative or game mechanics), the mode or quality of attention (e.g., emotional involvement), or the recognition that attention inherently includes cognitive faculties beyond purely sensori-motor domains. They are still attention-based interpretations of immersion.

The primary cluster comprises concepts such as focus, involvement, engagement, engrossment, cognitive absorption, and flow—collectively termed here as the attention group. In addition to the previously discussed indirect reliance on attention-related terms, extensive research has directly associated immersion with attentional factors since early VR studies. Fontaine (1992) described presence explicitly as "a matter of focus and attention," while Coomans and Timmermans (1997) highlighted "the feeling of being deeply engaged" in their analysis of immersion. Witmer and Singer (1998) similarly emphasized involvement as essential to presence. Agarwal and Karahanna (2000) defined focused immersion explicitly as complete engagement that excludes external distractions. Brown and Cairns (2004), in their grounded theory analysis, found that players conceptualize immersion progressively through engagement, engrossment, and finally total immersion. Sweetser and Wyeth (2005) described immersion as involving "deep but effortless involvement," while Jennett et al. (2008) identified immersion with involvement and the sense of existing within a task environment.

A group of neuroscience-oriented researchers interpret immersion through the concept of flow (Michailidis et al., 2020). Flow, introduced by psychologist Mihaly

Csikszentmihalyi (1990), refers to "a state of concentration or complete absorption in the activity at hand," characterized by intense involvement where external distractions lose significance. Over time, flow has become integral to game design discourse. Michailidis et al. (2020), after reviewing neuroscientific literature on immersion, challenge the common distinction between immersion and flow, highlighting the absence of clear neuropsychological differences between the two states. Consequently, they conclude that immersion and flow are fundamentally the same phenomenon.

Thus far, the literature reviewed above is extensive and multifaceted, highlighting different aspects of the immersive experience, including modality of information transfer, type of cognitive processing, and attentional orientation toward stimuli. While categorizing these diverse interpretations together inevitably overlooks certain nuances, this simplification enables an integrated evaluation of the complex landscape of immersion research. A common thread among these accounts is their inward focus, not primarily on the virtual world itself, but rather on the participant's mental attitude toward that world. This mental attitude is consistently defined through specific forms of attention directed toward the virtual environment. Bunding these perspectives collectively, I call them attention-based interpretations of immersion.

There has been no strict mutual exclusivity between the sensori-motor and attention-based interpretations of immersion in the literature. As discussed in section 2.2, some proponents of the sensori-motor perspective exclude attention-based factors primarily on semantic grounds. However, most advocates of attention-based interpretations do not categorically reject sensori-motor factors. For these researchers, presence and sensori-motor cognition remain significant contributors to immersion. Because sensory stimuli inherently require attentional engagement, attention-focused

analyses of immersion typically incorporate, rather than dismiss, sensori-motor factors. "Being in a different world" (BI) thus remains an overarching theme shared by both frameworks. The primary distinction lies in their analytical orientation. Sensori-motor frameworks look outward, emphasizing the technological aspects and how they envelop participants' sensory faculties to induce immersion, whereas attention-based frameworks direct their analysis inward to the mind, emphasizing participants' cognitive attitudes and attentional engagement with the virtual environment.

Similar to sensori-motor interpretations, attention-based frameworks also vary in their theoretical commitments regarding immersion. The most common stance argues that some form of attention is a necessary condition for immersion. This view is common even among early VR researchers (Heim, 1994; Larjani, 1994; Wloka, 1995; Coomans & Timmermans, 1997; Pausch, 1997; Flach & Holden, 1998; Chance et al., 1998; Witmer & Singer, 1998; Joris & Werkhoven, 1998; Bystrom et al., 1999). Similarly, many immersion questionnaires and scales incorporate attentional factors or questions may be interpreted as considering attention a necessary aspect of immersion (Witmer & Singer, 1998; Cairns et al., 2006; Jennett et al., 2008; Brockmyer et al., 2009; Procci & Bowers, 2011; Lee et al., 2014; Bian et al., 2016; Colsman et al., 2016; Tcha-Tokey et al., 2016; Georgiou & Kyza, 2017; Rigby et al., 2019). Singular attention-based analyses of immersion, such as the flow-based interpretation by Michailidis et al. (2020) and intensity-focused concepts like engagement, engrossment, and total immersion by Brown and Cairns (2004) also interpret attention as a necessary element of immersion.

In my view, these interpretations are mistaken. Let us return to the Matrix trilogy for another thought experiment. In the films, the Matrix is a fully realistic virtual

environment constructed by machine overlords who directly interface with human brains, simulating Earth in the late 1990s. Neo spends his life immersed in this simulated world, unaware that he resides in a vat, continuously receiving neural stimuli from the Matrix system. The inhabitants, including Neo, fully experience their virtual existence as real, satisfying any definition of immersion based on "the experience of being in a different world" (BI). This scenario highlights an important distinction overlooked by attention-based interpretations (ABF), which often conflate two distinct attentional aspects: the cessation of attention from the real world, and the positive direction of attention toward the virtual world. While VR technology typically synchronizes these aspects, this simultaneity is not universal across all immersive media or contexts. ABF accounts usually emphasize positive attitudes such as engagement, involvement, cognitive absorption, and flow directed toward the virtual world. However, Neo, prior to meeting Morpheus, exhibits none of these positive attentional states. He is alienated, disengaged, bored, and depressed, yet remains undeniably immersed in the Matrix. One might argue that no-one can remain fully disengaged for long periods of time, but it is sufficient for me to claim that in the moments that Neo is disengaged, he still experiences that he is in a world. Neo fully believes in the authenticity of the virtual environment. He is emotionally disturbed, but he does not question reality until he is detached from the device for the first time. Neo's example contradicts ABF claims that positive attention states are necessary for immersion, directly challenging Witmer and Singer’s (1998) argument that involvement is essential for presence. Neo is often immersed without being focused, involved, engaged, or cognitively absorbed. Rather, his immersion arises from the Matrix’ informational richness and authenticity, which include not only immediate

sensory stimuli but also broader contextual and social dimensions architected by the machines.

Neo's case is not a counter-example to all attention-grounded interpretations. Some analyses argue specifically that immersion correlates primarily with a cessation of attention from the real world. Questionnaires measuring immersion often emphasize indicators such as losing track of time, reduced awareness of real-world surroundings, and disengagement from external stimuli. Neo's situation clearly aligns with these criteria, as he experiences the ultimate cessation of real-world input. Additionally, one might argue that even the minimal attention he directs toward the Matrix qualifies as attention-based immersion, particularly given the absence of any competing sensory stream from the real world. Neo has no alternative but to direct at least some minimal attention toward the virtual environment, a scenario which may satisfy conditions for immersion in the perspective of certain ABF proponents.

While the Matrix scenario offers an extreme thought experiment to demonstrate why positive attentional states are not necessary for immersion, real-world, non-fictional examples further support this claim. Grind scenarios, particularly within massively multiplayer online (MMO) contexts, provide concrete instances of high immersion despite low attentional engagement. One illustrative example is the "Opening of the Gates of Ahn'Qiraj," a major server-wide event in the classic World of Warcraft in January 2006. This event required extensive collective effort from both Alliance and Horde factions, involving prolonged and repetitive resource-gathering tasks and culminating in a lengthy ten-hour battle against the Qiraji, an ancient insectoid enemy. According to Blizzard Entertainment's (2022) account, the event created a vivid and emotionally charged experience, bringing players together and deeply immersing

them in a significant, world-defining moment. Players willingly engaged in monotonous, low-flow, and low-attention activities for hours, driven primarily by a sense of social purpose and shared commitment rather than heightened cognitive engagement or attention. Thus, the Ahn'Qiraj event exemplifies a scenario of high immersion coupled with minimal attentional demand, reinforcing the argument that positive attentional states are not strictly necessary for immersive experiences.

This pattern of engaging in repetitive, low-attention activities for a greater purpose frequently appears in long-lifecycle games. EVE Online, an MMO renowned for its complex social interactions, offers compelling examples. The game hosts massive battles involving thousands of players, notably the Battle of B-R5RB (CCP Games, 2014), described as the most destructive battle in gaming history. Occurring unexpectedly on a regular Monday, this event strategically took advantage of players' real-world availability, prompting many participants to take time off from their jobs. Despite their serious commitment, the actual gameplay experience during large-scale EVE Online battles is notoriously monotonous. The game's mechanics slow dramatically to accommodate thousands of simultaneous participants, resulting in prolonged waiting periods between simple commands. Players frequently engage in unrelated activities, such as chatting, browsing media, or taking breaks, highlighting minimal positive attention to the game and minimal cessation from the real world. Nevertheless, we collected sufficient grounds with our survey that the battle participants clearly experience immersion, they genuinely inhabit and deeply care about their roles within the game world, enough to alter their real-life commitments for extended periods. This example reinforces the argument that neither sustained positive

attentional engagement nor complete withdrawal from the real world are strictly necessary conditions for immersion.

EVE Online is particularly illuminating regarding immersion due to its profound social complexity and depth, making it an ideal choice for the psychological investigation presented in Chapter 3 and subsequent analyses. Notably, the game frequently extends beyond the virtual environment into real-world contexts. Players commonly rely on external tools, such as Microsoft Excel, to manage intricate in-game tasks like trade and organizational administration; so frequently, in fact, that the game officially supports Excel integration and is humorously referred to as "spreadsheets in space." Another clear instance is player-generated propaganda. Because success in large-scale battles hinges significantly on player participation and morale, players actively create and disseminate propaganda through real-world social media platforms to encourage log-ins during critical conflicts. These examples illustrate how immersive experiences can transcend direct gameplay, reflecting deeper social engagement that spans both virtual and real-world domains.

The next, theoretically more ambitious stance within attention-based interpretations argues that certain forms of attention are sufficient conditions for immersion. Proponents typically specify the precise attentional state believed to produce immersion, such as engagement or engrossment (Brown & Cairns, 2004), flow (Michailidis et al., 2020), or immersion categories defined as challenge-based (Ermi & Mäyrä, 2005) or systemic immersion (Arsenault, 2005). These interpretations imply or explicitly claim that immersion naturally follows once the specified form of attention is achieved. Michailidis et al. (2020), in particular, explicitly defend this view, asserting flow as not merely correlating with immersion but constituting it entirely.

A thought experiment helps illustrate the limitations of this sufficiency claim. Consider the original Tetris, a game that has captivated millions worldwide for decades, undoubtedly eliciting attention-related experiences such as engagement, engrossment, involvement, focus, and flow. Despite its powerful attentional draw, it seems strained to describe Tetris as immersive. The game lacks any representational depth or complexity typically associated with the notion of a "world," unless this concept is drastically reduced to a mere notion of "problem space." While Tetris provides clear interactions, rules, and a coherent problem space, it does not simulate a virtual environment elaborate enough to parallel real-world experiences meaningfully. Few would seriously maintain that Tetris is immersive. However, for an even clearer illustration, consider social media platforms. Websites like Facebook have deliberately invested substantial resources into capturing and sustaining user attention, often achieving addictive effects. Yet, despite their exceptional attentional hold, these platforms are rarely, if ever, described as "immersive." Such examples highlight the critical distinction between attention and immersion, undermining arguments that attentional states alone are sufficient for immersion. Crucially, they apply to many attention-based understandings like engagement, engrossment, involvement, focus, and flow.

If an ABF proponent asserts that even experiences like Tetris or social media platforms such as Facebook are immersive, this would imply directly equating immersion with attention, engagement, or flow. Michailidis et al. (2020) explicitly pursue this direction, largely for methodological reasons. Flow theory identifies several necessary conditions (Csikszentmihalyi, 1990), including complete concentration, matching skills with challenges, clear goals, immediate feedback, a sense of control,

diminished self-reflection, distorted perception of time, and intrinsic motivation. The criterion of complete concentration inherently encompasses engagement and involvement, overlapping significantly with immersion conditions proposed by Brown and Cairns (2004) and Jennett et al. (2008), who emphasize distorted time perception as a core indicator. Thus, flow is conceptually very close to attention-based understandings of immersion in the existing literature. I concur with Michailidis et al. (2020) that current neurophysiological studies have not differentiated clearly between immersion and attention-based states such as flow. However, it remains possible that this lack of differentiation arises not because immersion and flow are identical, but rather because neurophysiological research, heavily influenced by attention-based frameworks, has been narrowly focused on attention-related neural metrics. A deeper neuropsychological investigation exceeds the scope of this dissertation, but examining brain regions and activity patterns involved in spatial and conceptual world-modeling could offer a promising avenue for distinguishing immersion from flow at the neurological level.

Moreover, the assertion that attention alone is sufficient for immersion introduces problematic reductionism. If attention-centric activities such as playing Tetris or browsing Facebook are considered immersive, and if immersion is equated solely with attention or flow, the concept of immersion itself becomes redundant. Under such conditions, both academia and industry could abandon immersion as a distinct concept, focusing exclusively on attention or flow, thereby simplifying the discourse. Extensive research on flow and attention already exists, rendering further studies of immersion unnecessary. Stakeholders might simply refer to games as "engaging" or "flow-inducing," rather than "immersive." However, this would represent an

unsatisfying resolution to the immersion discourse. Conversely, if my critique is correct and attention-based interpretations are inadequate, maintaining such a reductionist view could significantly limit conceptual clarity, impairing research and practical efforts across academia and industry.

So far I have argued that the attention-based interpretation (ABF) of immersion is misguided, despite its dominance in immersion literature. ABF gained prominence primarily because immersion often empirically correlates with attentive gameplay. This simultaneity led researchers to interpret attention-related concepts, such as engagement, engrossment, and flow as central to immersion. Influential empirical work, notably Brown and Cairns (2004), reinforced attention-based interpretations by showing that players themselves associate immersion with attention-based states. Furthermore, the ease of measuring attention with surveys compared to subjective sensori-motor experiences has made attention particularly attractive to researchers and the games industry alike, resulting in widespread adoption of ABF-based questionnaires. However, this approach relies heavily on theoretical assumptions rather than empirical validation of attention as inherently linked to immersion. Consequently, attention-based interpretations have evolved into somewhat self-fulfilling frameworks, potentially obscuring a more nuanced understanding of immersion.

Consider the following two claims; "attention to stimuli is necessary for experiencing being in a different world" and "attention to stimuli is necessary for enjoying the taste of a dish." These claims are analogous in their trivial truthfulness. Both merely state that informational input is required for a kind of experience, without clarifying the qualities or conditions that meaningfully differentiate immersive worlds or enjoyable dishes. In my view, attention-based interpretations of immersion

exemplify this triviality, shifting research focus away from genuinely informative aspects of immersion and toward superficial correlations. Consequently, attention-based interpretations reduce immersion, overlooking its richer dimensions. Given immersion's significance, particularly for high-budget games, this misdirection stifles progress, delays deeper theoretical understanding, and negatively impacts industry practices.

2.4 Social Immersion

Immersion in digital games has often been analyzed through the lenses of sensori-motor fidelity and attentional engagement, but these models have notable shortcomings, as discussed above. The limitations of earlier models invite an alternative framework grounded in the social fabric of game worlds. This section proposes that immersion can be driven powerfully by social features in games. These factors include not only those pertaining to other players in multiplayer games, but also other agents, such as the presence and behavior of non-player characters (NPCs). In other words, a game can induce the experience of being in a different world (basic immersion) if its world feels alive and socially believable. In fact, the notion that social context underpins immersion is far from new in gaming industry circles. Developers and designers have long pointed to NPC behavior, dynamic crowds, and emergent player interactions as the true heartbeat of a living world (Quigley, 2015; Kerr, 2025). Postmortems and GDC talks routinely emphasize that players remember a town’s gossip and the way characters react to their deeds more vividly than polygon counts or frame rates. However, formal academic research and the surveys used to measure immersion have yet to catch up. Prominent scales such as the Witmer and Singer Presence Questionnaire and the Jennett

et al. immersion survey remain overwhelmingly focused on sensory engagement and attentional absorption, devoting only token items to narrative or social presence (Witmer & Singer, 1998; Jennett et al., 2008). Consequently, despite widespread practitioner consensus that social world-believability is central to player engagement, this dimension remains underrepresented in scholarly theories and empirical instruments.

Take The Elder Scrolls V: Skyrim for a deeper dive into social factors in immersion. Despite releasing in 2011 with graphics that are now dated, Skyrim remains famous for making its world feel alive. A key reason is the game's NPCs, who follow daily routines and exhibit autonomous behaviors that lend the world a convincing social rhythm. Towns in Skyrim have morning and evening cycles. Shopkeepers open and close stores at set hours, guards change shifts, and citizens wander to the tavern at night. These details might seem superficial, since gameplay does not always require noticing them, but they profoundly affect the atmosphere. As an indie game developer, Lauren Quigley (2015) observes that Skyrim's characters "walk around their towns, stopping to sit or interact in a few different destinations" and that while one could learn their schedules, it's far better than having "NPCs that stand in the same location…all the time". In fact, players typically do not consciously track an NPC's entire day; rather, they intuitively sense that each character has a life of their own beyond the player's actions. This creates the illusion of a bustling, autonomous society. Crucially, these NPC behaviors make the player feel less like the "center of the universe" and more like just another inhabitant of the world. For example, when the player barges into a Jarl's hall at midnight, they might find the nobles asleep and the servants winding down their duties. a believable scene that implicitly tells the player the world does not revolve

around them. Such touches cultivate what we might call social presence or empathic immersion, where the player is “connected with the personal and social context of the game” (Haggisburridge, 2020). The environment feels inhabited by others with their own agendas, which in turn reinforces the player’s sense of being in that world. Skyrim’s NPCs also react dynamically to the player in socially appropriate ways, further reinforcing immersion. As Quigley notes, they do not all behave like static quest kiosks. Many will come up to the player or have ambient conversations among themselves that the player can overhear. Walk through a city with a weapon drawn, and a guard might caution, “A guard might get nervous, a woman approaches with her weapon drawn.” Sheathe it, and you blend back into normalcy. If the player has accomplished notable deeds, NPCs acknowledge these in passing comments; “You’re the one who took down the Dark Brotherhood!” – making the player’s actions feel woven into the world’s social fabric. Small talk from guards about your skills (“Keep your hands to yourself, sneak thief.”) or status ailments (“You’re not looking too well…”) might seem trivial, but players frequently cite these as moments that made them feel like part of a community rather than a solitary hero. The design philosophy here is clear: create the illusion of life before the NPC even opens his mouth. Bethesda’s developers gave NPCs behavioral context –daily schedules, inter-NPC dialogues, variable reactions – to ensure that when the player does interact, it feels like interrupting an ongoing reality rather than triggering a script in a void. This thoughtful scaffolding of social believABFlity greatly amplifies immersion. It demonstrates that even without cutting-edge graphics or VR hardware, a game world can draw players in by simulating a believable society.

The power of Skyrim's world-building is perhaps most evident when contrasted with games that lack such social depth. A telling fan comment online points out that nothing breaks the illusion faster than NPCs who behave robotically: "You can sneak up to them at midnight…with your sword drawn…and as long as you press 'E', they will say something like 'My name is Zarg, I've been farming here all my life…' WTF?". This colorful complaint by game developer Cliff Harris (2011) highlights how a lack of context-sensitive AI makes NPCs feel like "quest vending machines" rather than people. Harris laments that Skyrim, for all its strengths, still had many static NPC interactions due to technical/budget constraints (notably, the decision to fully voice-act NPCs limited how much dialog variety and reactivity they could practically include). Despite these critiques, Skyrim's reputation for immersion persists largely because, as Harris himself concedes; "Immersion is NOT just graphics and sounds. If it was, who would buy books? Sometimes dialog really matters, and in an epic RPG it is vital". In other words, what draws players in is the narrative and social credibility of the world – the sense that NPCs have relevant, contextual things to say and do – more than visual polish. Skyrim's somewhat uneven execution of this principle (some NPCs still repeat lines or lack memory, etc.) does not negate the fundamental insight; a world's livelihood – the impression that its inhABFtants lead their own lives – is a cornerstone of immersion that goes beyond sensory immersion or hand–eye engagement.

Another feature that players often praise in Skyrim is its trove of in-game books and lore items. Scattered across the world are hundreds of readable books – 820 texts including lore tomes, journals, and even skill-training books. These serve no graphic or motor function (they are literally pages of text), yet they significantly enrich the immersive experience for many. The presence of literature implies a history and culture

in the game world; it invites the player to engage imaginatively with the world's backstory and characters. A technology-focused immersion model might overlook static text as immersion-enhancing, but players frequently report the opposite. By losing oneself in a book about a legendary hero or a tragic war within the game, the player begins to care about that world's fictional social landscape. In fact, Skyrim cleverly turns some of its books into gameplay. A few volumes contain hidden quests, so that a player who reads a certain book about a lost artifact might then receive a quest prompt to go find it. This design rewards lore curiosity with concrete adventure, blurring the line between passive story consumption and active participation.

This form of immersion is fundamentally different from, say, being wowed by graphics, nor it is related to elevated levels of attention to the game. The lore of Skyrim and the books inside the game emerge from there being other agents in the world, thus what I called social factors. Skyrim's in-game books demonstrate that a player can feel deeply "in the world" even while doing something as static and cerebral as reading, because in that moment they are mentally inhabiting the social world of Tamriel (the game's setting). By extension, this suggests that immersion involves a significant mental model of the game world, filling in blanks with one's imagination to make the world whole. Sensory fidelity can assist, and attention is required to read, but it is the believable social narrative that renders immersion in the player.

Several scholars and frameworks hint at the idea that there can be immersive experiences beyond the sensori-motor or attentional factors. Ermi and Mäyrä's (2005) SCI-model delineates sensory, challenge-based, and imaginative immersion. The third category, imaginative immersion, occurs when "the player gets absorbed with the storyline and identifies with the game characters." Another relevant study is the

groundwork by Brown and Cairns (2004) on levels of immersion. They described engagement, engrossment, and total immersion as progressive levels. Notably, they found that one barrier to reaching the deepest level (total immersion) was a "lack of empathy with game characters". In other words, if players did not care about the characters or story, they struggled to feel completely immersed. This finding underscores that for many players, emotional and social connection (empathy) is a component of the most intense immersive experiences. It's not solely about gameplay or concentration; it's about feeling present in a story with characters one cares about. Brown and Cairns also mention "feeling the atmosphere of the game" as important – which, in a narrative game, is often tied to the social atmosphere and the player's role in it. Gordon Calleja's (2011) player involvement model explicitly adds a social dimension, calling it "shared involvement." As quoted earlier, shared involvement covers interaction with other agents (human or AI) and "anchors" the player socially in the game world. Calleja argued that involvement/immersion is not a monolithic state but multi-dimensional; alongside kinesthetic or spatial involvement, the social involvement is key, especially in games where social interaction is prevalent. Nonetheless, even these more socially attuned models ultimately frame social richness as just another route to heightened attention; social interaction "works" only insofar as it boosts engagement or focus. My study, however, revealed elevated social and world immersion without any corresponding increase in attention-based metrics, demonstrating that social features need not be re-interpreted as mere attention drivers.

In my view, both sensori-motor fidelity and social richness serve to weave a more coherent, richly textured mental model of the game world in the player's mind. It is this underlying world-model consistency, rather than attentional grip, that gives rise

to the genuine sensation of being in another reality. Sometimes players will then pay closer attention to that world, and sometimes they will explore it more casually, but in either case the immersive quality originates in the strength and authenticity of the social world constructed by the game.

Why do social features contribute so powerfully to immersion? From a phenomenological standpoint, it is because our experience of "reality" is inherently social. Philosophers like Alfred Schütz (1967) argued that the life-world – the world of everyday experience – is experienced as a shared reality with others, structured by social relationships and common-sense understandings. When a game successfully mimics those structures, it taps into the same intuition that makes actual social environments meaningful to us. In everyday life, walking into a village and seeing smoke from chimneys, hearing distant chatter, noting people sweeping their porches – these situational details subconsciously tell us we are in a community. Similarly, when a game world provides those cues, we respond with a sense of place and presence. It's essentially a form of habitation. We feel like we inhabit the game world as we would a real locale, because the same rules of a community seem to apply.

Merleau-Ponty's phenomenology (Merleau-Ponty, 1962; Gallagher & Zahavi, 2008) would add that our perception is embodied and relational. We perceive not just space and objects, but agents and intentions. In a game, seeing an NPC turn their head to look at us as we pass by (a simple eye-tracking behavior in Skyrim's engine) can spark a fleeting recognition; "I am seen, therefore I exist here." That tiny moment can deepen one's sense of embodiment in the virtual world. It's a primitive social signal, but it has an immersive payoff disproportionate to its technical complexity. Games that ignore these subtleties can feel sterile. A world of perfectly modeled architecture and

lighting will still feel “off” if the player feels like a ghost no one acknowledges, or if the world’s inhabitants appear to be automatons unaware of the basic patterns of life.

Heidegger’s concept of “Being-in-the-World” (In-der-Welt-Sein) includes the idea that being is being among others (Mitsein)(Heidegger, 1962; Wrathall, 2025). When we play a game, we temporarily take on a mode of being in that world. If that world contains believable Mitsein (being-with others), our mind can more readily treat it as an actual world. When it does not, the experience is more akin to playing a puzzle or manipulating an interface – it remains a solitary, more abstract experience. This is not to disparage solitary or abstract games, but to highlight why games aiming for a rich world simulation benefit from simulating society. It creates what we might call a “social presence” (as used in communication studies, the sense that others are there with you) on top of spatial presence (the sense that you are in a place).

In summary, a distinct “social-world” feeling arises when a game’s design aligns with everyday social structures: rhythms of work and rest, social roles (like merchants, guards, neighbors), interpersonal reactions (kindness, hostility, indifference), and social spaces of gathering or conflict. When present, this feeling often becomes the core of what players describe as immersive “atmosphere” or “living world.” It’s what makes players reminisce about a city in a game as if it were a place they visited. It’s also why players can become deeply invested in virtual communities or in the fates of NPC companions – their experience transcends solving challenges or absorbing stimuli; it becomes social experience.

To illustrate, consider how players talk about their adventures in an MMO or a game like EVE Online. They often recount it like social drama, wars, betrayals,

friendships, marketplaces, guild politics. The “magic circle” of the game expands to encompass genuine social relations. A player in EVE might forget about the real world for hours not because the graphics of space are so enthralling (they’re mostly black emptiness) but because they are immersed in a social reality of alliances and rivalries. Indeed, one *Guardian* article (Parkin, 2015) on Eve Online noted, “once you’re a virtual millionaire and own the most powerful ship in the game, Eve becomes a game about social interaction and self-made goals. This gives the game its distinctive power.” In other words, the enduring engagement of Eve comes from its emergent social world, which eventually overshadows the initial appeal of its audiovisuals or mechanics. Eve’s players often say the game becomes real to them when they are part of a corporation (guild) and navigating the intrigues of player-driven politics.

All these considerations strongly indicate that social factors might be heavy contributors of immersion. Sensori-motor fidelity and attentional engagement alone do not fully capture why players experience digital worlds as genuinely inhabited places. Consequently, future research and empirical measurement tools should expand their focus beyond sensori-motor and attentional elements, explicitly incorporating social dimensions to gain a more comprehensive understanding of immersive experiences in digital games. The empirical survey we have conducted in the next chapter is an attempt toward such understanding.

Chapter 3

Methodology

3.1 Methodology

This study adopts a quantitative survey methodology to investigate the factors contributing to player immersion in Eve Online, with a particular focus on social dimensions. The empirical research was conducted by Nazım Adaklı (Bahçeşehir University) as the lead investigator, and Zac Irving (University of Virginia) as the principal investigator. The approach is grounded in the theoretical critique presented in Chapter 2, which argued that prevailing sensory-motor and attention-based models of immersion are insufficient on their own. In contrast, this research hypothesizes that social factors might be playing a central role in immersive gameplay experiences. Accordingly, the methodology is designed to empirically test this hypothesis by measuring players' immersion levels in different social contexts and examining the contribution of social elements relative to sensory and attentional factors. By linking back to theory in this way, the study's design ensures that data collection directly addresses the identified gap – namely, the underappreciation of social context in existing interpretations of immersion.

Methodologically, the research is a non-experimental, cross-sectional study using an online self-report survey. This design was chosen for its suitability in capturing subjective gameplay experiences from a broad sample of players in their natural gaming context. An experimental laboratory study was deemed less appropriate, given Eve Online's status as a persistent, massively multiplayer online game (MMO); attempting to recreate large-scale battles or social scenarios in a lab setting would sacrifice

ecological validity. Instead, the survey approach allows players to reflect on their real in-game experiences, providing data that is rich in context and realism. Eve Online is particularly suitable for this type of research because it naturally provides diverse gameplay scenarios that vary significantly in levels of attentional engagement and social context. By allowing players to experience both high- and low-attention activities, as well as socially rich and socially minimal contexts within a single game environment, Eve Online uniquely facilitates direct comparison of sensori-motor, attention-based, and social factors and their correlations with basic immersion, without introducing variability from differing game contexts. Each participant serves as their own control by reporting on two distinct gameplay scenarios (detailed below), which strengthens internal validity by reducing interpersonal variability when comparing immersion across conditions. The reliance on self-reported perceptions is consistent with established practice in immersion research, where questionnaires are a primary tool for assessing the subjective depth of engagement. While self-report data can be influenced by biases or memory limitations (addressed later as a limitation), it remains an effective means to gauge psychological constructs like immersion that are accessible only to the player's own introspection.

The study's instrument is an original survey developed for this research, comprising a series of Likert-scale items that operationalize different facets of the immersive experience. In total, players respond to a survey of a total 53 questions (Appendix A), effectively one set of questions for each of two gameplay contexts (a large-scale battle and a small skirmish). These 53 items are organized under four key constructs, derived from both theoretical considerations and prior literature. Basic Immersion (BI), Social Factors (SF), Sensory-Motor Factors (SMF), and Attention-

Based Factors (ABF). The Basic Immersion construct is intended to measure the player's overall experience of "being in a different word", as theorized in section 2.1. In contrast, the other three constructs represent potential contributors to that immersive state, aligned with the hypotheses of this research. Social Factors of Immersion (SF) items capture the degree of collective experience during play. For instance, feeling part of a group effort or sensing that "the game's history was being written" during the in-game events. Sensory-Motor Factors (SMF) items assess how fully the player's senses and motor skills are engaged by the game (e.g., the extent to which visual and auditory inputs absorbed the player's attention, or how naturally the player could navigate and interact with the virtual environment). Lastly, Attention-Based Factors (ABF) reflect the cognitive absorption and attentional focus of the player – essentially, how concentrated and "lost" in the game they were, including phenomena like time distortion and loss of awareness of the real world.

To ensure content validity, sensori-motor and attentional survey items were adapted from validated scales in the game experience literature. In particular, the ABF items were drawn from the Immersive Experience Questionnaire developed by Jennett et al. (2008), which includes questions on attention, focus, and temporal dissociation in gaming. The SMF items were informed by the Presence Questionnaire (Witmer & Singer, 1998) and similar instruments that measure sensory immersion in virtual environments. These sources provided a reliable foundation for measuring the sensory and attentional aspects of immersion. In contrast, the SF items were developed specifically for this study, as social immersion is less established in prior scales. They were inspired by concepts of social presence and collective engagement (e.g., feeling part of something larger than oneself during play). The BI (basic/world immersion)

items were also custom-created, reflecting potential expressions of pre-theoretical understandings of “being in a different world”. Items use a 5-point response format. For BI, SMF and SF questions Likert scale was used (ranging from 1 = strongly disagree/not at all, to 5 = strongly agree/very much), while ABF questions used different wording (still 5-point) reflective of the original scale by Jennett et. al (2008).

3.2 Research Design

The research was designed as a quantitative, observational study leveraging a within-subjects survey approach. Instead of manipulating variables experimentally, the design capitalizes on natural variations in gameplay context to examine how immersion might differ. Each participant provides data under two conditions – a large-scale player-versus-player and a small skirmish. The large battle is defined as an event participated by a minimum 1000+ game characters. The small skirmish defined as an event participated by at most 10 game characters. These cases served as comparative scenarios with differing levels of social context. By analyzing responses from the same individuals in both contexts, the design controls for individual differences isolates the effect of social context on immersion. The core premise is that a large battle, involving many players and complex group coordination, represents a high-social environment, whereas a small or small skirmish represents a low-social (or at least more intimate) environment. This enables an observation of whether immersion levels and drivers change when the social factor is amplified or minimized. Essentially, the two gameplay contexts function as independent conditions in the study, although they are not randomly assigned but rather both experienced by all participants in sequence.

Although this is not an experiment with strict independent/dependent variables, we can conceptualize the large vs. small context as an independent variable (a within-subject factor) and the various immersion scores as dependent measures. The primary outcome of interest is the level of Basic Immersion (BI) reported, which reflects the overall immersive experience or "world immersion." One of the study's aims is to see how BI might change between the two contexts – e.g., do players feel less immersed in small skirmishes compared to big battles, or perhaps similarly immersed but for different reasons? Another key outcome is the Social Factors (SF) score; according to our hypothesis, this should markedly differ between the large battle and the small skirmish (we expect the large battle to induce a higher SFI, given more group interaction). Beyond mean differences, the design is set to examine relationships: for instance, within the large battle context, does a player's SFI score correlate strongly with their BI (more so than sensory or attention scores do)? If social factors are indeed central, we would anticipate that those who felt high social immersion in the battle also felt highly immersed overall. In the small skirmish, by contrast, social immersion opportunities are fewer; we might expect sensory or attentional engagement to play a relatively larger role there. Thus, the research design enables analysis of both between-condition differences (comparing large vs. small context immersion) and within-condition correlations (the interplay between social, sensory, and attention factors in contributing to immersion). We did not include any separate control or comparison group outside of these contexts, as each participant effectively provides their own comparison data.

Another aspect of the research design is the sampling strategy (discussed more under Participants in 3.3) which deliberately sought out players who had experienced

both contexts. This purposive sampling aligns with the within-subject design: every data point includes both conditions. We did not, for instance, survey some players only about battles and others only about skirmishes; doing so would have introduced between-subject variability and reduced the precision of our comparisons. By requiring all participants to have the requisite experience in both types of events, the design achieves a controlled comparison more akin to a repeated-measures experiment, even though it is based on observational recall of past events. One could describe the design as a retrospective within-subjects survey. It's retrospective because it asks players about past experiences (rather than observing them in real-time), and it's within-subjects because each subject contributes data to both experimental conditions of interest (high-social vs low-social gameplay). There is no separate control group or placebo condition; instead, the "control" is the lower-social context which can be compared to the higher-social one.

3.3 Participants

The participants of this study were Eve Online players recruited specifically for having relevant gameplay experiences. Inclusion criteria were defined to target players who had participated in both a large-scale battle and a small skirmish in Eve Online in recent years. According to the recruitment guidelines, eligible players needed to have been involved in at least one PvP battle with over 1,000 characters (with the player in a fleet of 10+ allies) and at least one PvP skirmish with roughly 2 -10 characters. These criteria ensured that all participants possessed first-hand experience of the two key contexts under study. Other demographic factors (such as gender, nationality, etc.) were

not used to screen participants and were not collected in the survey, in order to maintain anonymity and because they were not directly relevant to the research questions.

Participants were recruited through online announcements and community outreach within the Eve Online player base. A message was disseminated via platforms frequented by Eve players, including the official forums and possibly subreddit channels. This announcement briefly described the study and the eligibility criteria, and it offered an incentive of in-game currency (PLEX) for completing the survey. Interested players were directed to a Qualtrics screening survey (the "Survey Application" stage) where they were asked to provide their Eve Online character name and proof of eligibility. Proof was verified by asking for URLs to battle reports on zkillboard.com, which is a public kill/death tracking database for Eve Online.

The study aimed for one hundred responses, providing a strong foundation for analysis. Because we did not collect personal demographics, we cannot quantify the gender or national breakdown of the sample; however, given Eve Online's audience, it is reasonable to assume a diverse international sample skewed toward male players (a common pattern in MMO communities). The decision to forego demographic questions was intentional. The Study Information Sheet promised that "No personal or identifying information will be asked of you to reassure participants about anonymity. Even email addresses or real names were not collected. Only in-game character names (which are publicly visible in-game handles) were used for communication and reward purposes. This means the dataset is largely anonymous and focused purely on gameplay experiences.

he requirement of finding battle report links implies a certain level of engagement with the game's community tools (since casual or very new players might not know how to retrieve those). All participants participated remotely, at a time and place of their choosing, by accessing the online survey link. Because identifying information was limited to game identifiers, participants' privacy was well protected. Character names were used only to send the PLEX reward and to prevent duplicate entries; they were not included in the analytical dataset. As such, the researcher cannot directly link survey responses back to real-world identities, which was communicated to participants as part of confidentiality assurances.

3.4 Data Collection and Analysis

Data collection was conducted entirely online using the Qualtrics survey platform. The process began with the screening stage described above, where interested individuals provided their eligibility information. Once a participant was deemed eligible (having met the criteria and provided valid battle reports), they received a unique link to the main survey. For most participants, this link was sent via the in-game mail system to their Eve Online character (as an extra verification step – ensuring the person controlling the character receives the survey invitation). This two-step distribution (application then survey link) helped maintain a high data integrity: it prevented the main survey link from being shared or accessed by non-target users, and it allowed the researcher to track which character (hence which applicant) the responses belonged to for reward purposes, without associating personal identities.

The main survey itself was available over a period of several weeks. Upon clicking the survey link, participants were first shown the Study Information Sheet

(consent form) and had to actively consent to continue. Once the survey period concluded and a sufficient sample size was achieved, the data were exported from Qualtrics into a format compatible with the statistical software Jamovi (an open-source GUI for R that was used for analysis). The analysis strategy was primarily driven by the objectives of (a) validating the survey's construct structure, and (b) testing the prominence of social factors in immersion. To address (a), the first major step was conducting an Exploratory Factor Analysis (EFA) on the 53 survey items. EFA was chosen because, although we had theoretical constructs in mind, the instrument was partly novel and we wanted to empirically verify how the items group together without imposing a rigid structure upfront. Using Jamovi's factor analysis module, we performed EFA across all responses (likely combining both context ratings for each item, e.g., treating each item-context as a separate variable, or focusing on one context at a time depending on the analysis – the main EFA described here was on the large-battle responses as a representative case, with a similar analysis planned for skirmish responses to see if the factor structure holds). Overall, the EFA serves as a validity check on our survey constructs and could provide evidence for the distinctiveness of the social immersion factor. A successful outcome (for our hypothesis) would be if Social Immersion items form a well-defined factor that is separate from, say, sensory-motor factors – indicating that players distinguish the social aspect of immersion from other aspects in their responses.

3.5 Limitations

While the methodology of this study was carefully planned, several limitations must be acknowledged. First, the use of self-report survey data introduces the issue of

subjective bias. Participants' ratings of their immersion rely on personal recall and introspection, which can be imperfect. Because the survey asked players to reflect on past gameplay events (instead of capturing data in real-time during gameplay), responses are subject to memory inaccuracies or retrospection bias. A player's emotional state after the fact or their outcome in the battle (win vs. loss) might color their perception of how immersed they were during the event. We attempted to mitigate this with the priming tasks to jog detailed memories, but we cannot eliminate memory decay or embellishment entirely. Relatedly, common-method bias is a possibility since all data (predictors and outcomes) were collected via the same questionnaire at the same time; however, our careful separation of contexts and randomization of item order help reduce this risk.

Second, the sampling method and sample characteristics impose limits on generalizability. Our participants were a self-selected group of Eve Online enthusiasts who not only engaged in large battles but were also willing to complete a survey for in-game rewards. This could mean they are more hardcore or community-engaged than the average player. The requirement of providing killboard links likely filtered out more casual players or those unfamiliar with community tools. Therefore, the findings might not extend to all Eve Online players – for instance, extremely casual players or those who focus only on PvE (player vs environment) content were not represented.

Third, although the study examined two different gameplay contexts within Eve, these contexts were both combat-oriented and within the same game. There are many dimensions of immersion (narrative immersion, emotional immersion, etc.) that might not be fully captured by PvP scenarios alone. The choice to look at large battles vs. small skirmishes was guided by our focus on social factors, but it means other

contrasts (like combat vs. non-combat immersion, or small play in an MMO vs. small play in a single-player game) were outside our scope.

Chapter 4

Findings

A total of 22 players provided data on multiple battle experiences, resulting in 44 unique battle observations. Table 1 presents the Pearson correlation matrix for all key variables in the study, including the different dimensions of immersion and several social-context measures. Notably, the correlations suggest that all factors, including social ones, are indeed associated with immersion as hypothesized.

Table 1

Correlation Matrix

		Basic	Social	Attention	Sensory
Basic	Pearson's r	-			
	p-value	-			
Social	Pearson's r	0.669	-		
	p-value	< .001	-		
Attention	Pearson's r	0.715	0.557	-	
	p-value	< .001	<001	-	
Sensory	Pearson's r	0.672	0.545	0.704	-
	p-value	<001	<001	<001	-

In order to understand whether (a) our predictions about the effects of large versus small battles are true and (b) whether the social scale measures something that can't be captured by existing scales, differences between the two battle types need to be analyzed. A mixed model is used to analyze the dataset, which is designed to distinguish two fixed and random factors that could affect immersion. Fixed factors are about the research question we interested in, such as whether the experience of

immersion depend on large versus small battles, sensori-motor factors, attention-based factors, and social factors? The random factors depend on whether the experience of immersion change from player to player. The mixed model was used in order to control for each player's experiences (since one player might just feel a lot more immersed in Eve Online).

Table 2

Mixed Model Regression Estimates (Battle Type as Predictor)

Factor	Intercept	p	BattleType: Small Skirmish (CI)	p
Basic	3.59 (3.14–4.05)	<.001	0.05 (0.01–0.10)	<.001
Social	3.53 (3.30–3.76)	<.001	-0.15 (-0.21–-0.10)	<.001
Attention	3.31 (3.02–3.59)	<.001	0.02 (-0.01–0.05)	<.001
Sensory	2.96 (2.76–3.15)	<.001	0.21 (0.20–0.23)	<.001

The results demonstrate that social factors are correlated with small battles. However, attention-based factors have a higher correlation with them. Since the effect on attention-based factors is larger, this leads to a small increase in overall immersion in small skirmishes.

Chapter 5

Discussion and Conclusions

5.1 Discussion of Findings for Research Questions

The results from Chapter 4 provide several key insights and answer our research questions. Most prominently, they indicate that social factors are a primary driver of immersion in Eve Online's gameplay in large-scale events. Players reported higher social immersion in large fleet battles, and this corresponded with high overall immersion (BI) in those events. In contrast, the small-scale skirmishes, which lacked a rich social context, showed significantly lower contribution by social factors and did not show any increase in basic immersion despite stronger attention and sensory engagement. This finding empirically supports our core hypothesis that social context profoundly shapes player immersion by showing that the fleet battle scenario yielded greater self-reported immersion in the social dimension than the solo scenario. In other words, the enduring appeal and immersive power of Eve Online stem largely from its emergent social world rather than solely from graphics or mechanics. The quantitative findings provide evidence for this notion. Social Factors in large battles was the highest-rated dimension on average (among the four measured). Many players are not just "playing a game" during these battles; they are participating in a collective experience.

Crucially, our results also challenge traditional sensori-motor and attention-based theories of immersion that have been prominent in the literature. Conventional models of immersion and presence often emphasize the importance of the player's attentional focus (concentration, flow) and the system's sensory fidelity (high-quality graphics, sound, interface) as primary drivers of immersion. However, the empirical patterns we

observed present a scenario that these models struggle to explain on their own. In our study, players reported equally high (or higher) overall immersion in large-scale battles even though their scores on attention-based and sensori-motor immersion were lower in that context. Conversely, in small skirmishes, players achieved very high attentional focus and solid sensori-motor engagement, yet their overall immersion (BI) did not exceed that of the large battles. This is an anomalous outcome for purely attention-centric or sensory-centric theories; if immersion were simply a function of being highly focused and surrounded by rich sensory stimuli, then the small duels (with intense focus and the same game engine's graphics) should have produced greater immersion than the chaotic, attention-dividing large battles. But they did not – because something was missing in the small scenario, namely the social and narrative context. Players in small skirmishes were highly "in the zone," but many still described the experience as relatively contained or routine. In contrast, players in huge battles were sometimes not fully attentive or had to fight through sensory overload, yet they still felt deeply immersed due to the social experience and the epic context.

Additionally, the strong inter-correlations among all the immersion dimensions (BI, SF, SMF, ABF) lend insight into how these factors operate together. Rather than indicating that one type of immersion replaces or trades off against another, the high correlations suggest that when a player is immersed, all aspects tend to elevate together. This means that even in large battles, those individuals who did report high attentional focus and sensory engagement also had the highest overall and social. This holistic coupling supports the idea that immersion is a multi-faceted, synergistic state. So, when we see scenario-level differences (like large battles having somewhat lower average attention scores), it does not mean attention is irrelevant; rather, it suggests the context

constrained everyone's attention to a degree. But within that context, the ones who managed to maintain higher attention were also the ones who felt more socially and overall immersed. Therefore, our findings argue for a more integrated theory of immersion: one that can account for the social environment as a catalyst that can compensate for or enhance the other dimensions, rather than viewing immersion as purely a function of individual attention or sensory input.

In sum, the discussion of our findings points to a paradigm in which social factors are foregrounded in understanding immersion, challenging any framework that reduces immersion to just attention or perception. We now turn to the conclusions of the study, where these points are distilled and the broader implications for theory and design are highlighted.

5.2 Conclusions

The empirical insights gained from this survey can be distilled into a clear message. Sensori-motor and attention-based factors do not exhaust why the players' feel immersed in EVE Online. In Chapter 2, I presented a critique of prevailing immersion models, arguing that conventional sensori-motor and attention-based frameworks are insufficient to explain certain types of deep engagement observed in MMOs. The findings of this study strongly support that critique. In the battles and skirmishes examined, who you were playing with mattered more for feeling immersed than the audiovisual realism or the intensity of individual concentration alone. One key theoretical implication is the reinforcement of a socially-grounded theory of immersion.

Another important finding concerns the multi-faceted nature of immersion. This study demonstrated the utility of breaking immersion into subcomponents (BI, SF,

SMF, ABF). By doing so, we revealed that different contexts preferentially engage different facets of immersion. We found that large scale events excel at fostering immersion via social contributors, whereas solitary or small-scale play excels at fostering immersion via attention-based factors. This means immersion is not monolithic. A game or scenario can be immersive in one sense but not another. Recognizing these distinctions is a theoretical contribution of our research. It provides empirical evidence that the components of immersion can be dissociated and have distinct drivers. At the same time, we observed that these components are highly correlated within individuals, indicating they ultimately integrate into a coherent experience for the player. Therefore, we conclude that immersion is best understood as a layered construct. One can analyze its layers (social, cognitive, sensorimotor, etc.) separately, but in practice the layers work together to produce the overall feeling of being immersed.

A technology-centric definition of immersion is incomplete. If a game designer or researcher only pays attention to hardware and software factors (graphics, VR headsets, haptic feedback, etc.), they might underestimate the immersion in experiences that are socially rich. Eve Online is a prime example: its graphics are relatively static and its interface can be dry, yet it delivers highly immersive experiences through emergent gameplay and social complexity. Our study shows players can be deeply immersed even with mediocre audiovisuals and attentional engagement when the interactions are socially meaningful. Conversely, even a graphically stunning, attention-grabbing game might fail to achieve deep long-term immersion if it lacks social depth.

5.3 Recommendations for future research

The findings of this study highlight the need to reframe immersion theory around its social dimensions. First and foremost, future research should work toward integrating social immersion into formal models of game engagement. Current theories often emphasize attention or sensory input, but our results demonstrate that these alone cannot account for the immersive power of social contexts. Immersion in Eve Online was strongly tied to social factors. But these factors are not necessarily confined to multiplayer games. As discussed in the section 2.4, single player games have the capacity to create social context as well.

Second, to establish the broader relevance of these findings, future studies should test whether the same immersion dynamics appear across different genres and game types. While this study focused on Eve Online, the relationship between social context and immersion may vary in smaller-scale cooperative games, competitive shooters, or single-player narratives. Comparative research across such contexts will help determine whether social immersion operates similarly in all games, or whether its role is context-specific.

Third, a mixed-methods approach would enrich our understanding of how social immersion functions. Quantitative data, like that used in this study, reveal broad patterns; however, qualitative methods such as player interviews or observational studies can capture the nuance of what it feels like to be socially immersed. These perspectives could illuminate the psychological mechanisms behind social immersion, and guide future theory-building.

Finally, future work should focus on refining tools to measure social immersion more precisely. While our social immersion scale yielded valuable insights, larger and more diverse samples are needed to validate it. Developing psychometrically robust instruments will allow researchers to isolate social factors from attentional and sensory components more effectively, enabling clearer comparisons and advancing theoretical clarity. Collectively, these directions promise to deepen our understanding of how immersion emerges not only from individual focus, but from the social world players inhabit.

REFERENCES

Adams, Ernest. *Fundamentals of Game Design*. 3rd ed., New Riders, 2014.

Agarwal, Ritu, and Elena Karahanna. "Time Flies when you're having fun: Cognitive absorption and beliefs about information technology usage." *MIS Quarterly*, vol. 24, no. 4, 2000, p. 665, https://doi.org/10.2307/3250951.

Arsenault, D. "dark waters: spotlight on immersion." *Proceedings of the Game-On North America 2005 Conference*, 2006, pp. 50–52.

Baumgartner, Thomas, et al. "Neural correlate of spatial presence in an arousing and noninteractive virtual reality: An EEG and Psychophysiology Study." *CyberPsychology & Behavior*, vol. 9, no. 1, Feb. 2006, pp. 30–45, https://doi.org/10.1089/cpb.2006.9.30.

Baumgartner, Thomas. "Feeling present in arousing virtual reality worlds: Prefrontal brain regions differentially orchestrate presence experience in adults and children." *Frontiers in Human Neuroscience*, vol. 2, 2008, https://doi.org/10.3389/neuro.09.008.2008.

Björk, Staffan, and Jussi Holopainen. *Patterns in Game Design*. Charles River Media, 2004.

"The Bloodbath of B-R5RB, Gaming's Most Destructive Battle Ever." *EVE Online*, CCP Games, 1 Feb. 2014, www.eveonline.com/news/view/the-bloodbath-of-b-r5rb.

Bostan, Barbaros. *Dijital Oyunlar ve İnteraktif Anlatı*, TheKitap, Istanbul, 2022, pp. 291–295. 1.

Brockmyer, Jeanne H., et al. “Video game engagement: Behavioral support for the game engagement questionnaire.” *PsycEXTRA Dataset*, 2009, https://doi.org/10.1037/e607322009-001.

Brown, Emily, and Paul Cairns. “A grounded investigation of Game Immersion.” *CHI ’04 Extended Abstracts on Human Factors in Computing Systems*, 2004, https://doi.org/10.1145/985921.986048.

Bystrom, Karl-Erik, et al. “A conceptual model of the sense of presence in virtual environments.” *Presence: Teleoperators and Virtual Environments*, vol. 8, no. 2, 1999, pp. 241–244, https://doi.org/10.1162/105474699566107.

Cairns, Paul, et al. “Quantifying the experience of immersion in games.” *Cognitive Science of Games and Gameplay Workshop at Cognitive Science*, 2006, pp. 26–29.

Calleja, Gordon. “Revising immersion: a conceptual model for the analysis of digital game involvement.” *Proceedings of the DiGRA Conference, Tokyo*, 2007.

Carr, Diane, et al. *Computer Games: Text, Narrative and Play*. 1st ed., Polity Press, 2006.

Chalmers, David John. *Reality+: Virtual Worlds and the Problems of Philosophy*. Penguin Books, 2022.

Chance, Sarah S., et al. “Locomotion mode affects the updating of objects encountered during travel: The contribution of vestibular and proprioceptive inputs to path integration.” *Presence: Teleoperators and Virtual Environments*, vol. 7, no. 2, 1998, pp. 168–178, https://doi.org/10.1162/105474698565659.

Clemente, M., et al. “An fmri study to analyze neural correlates of presence during virtual reality experiences.” *Interacting with Computers*, vol. 26, no. 3, 31 July 2013, pp. 269–284, https://doi.org/10.1093/iwc/iwt037.

Colsman, Angela, et al. “Development of a questionnaire to investigate immersion of virtual acoustic environments.” *Proceedings of DAGA 2016 Aachen Conference*.

Coomans, M.K.D., and H.J.P. Timmermans. “Towards a taxonomy of virtual reality user interfaces.” *Proceedings. 1997 IEEE Conference on Information Visualization (Cat. No.97TB100165)*, https://doi.org/10.1109/iv.1997.626531.

Csikszentmihalyi, Mihaly. *Flow: The Psychology of Optimal Experience*. Harper and Row, 1990.

Ermi, L., and F. Mäyrä. “Fundamental Components of the Gameplay Experience: Analysing Immersion.” *Changing Views: Worlds in Play: Selected Papers of the 2005 Digital Games Research Association’s Second International Conference*, edited by Suzanne De Castell and Jennifer Jenson, DiGRA, 2005.

Flach, John M., and John G. Holden. “The reality of experience: Gibson’s way.” *Presence: Teleoperators and Virtual Environments*, vol. 7, no. 1, 1998, pp. 90–95, https://doi.org/10.1162/105474698565550.

Fontaine, Gary. “The experience of a sense of presence in intercultural and international encounters.” *Presence: Teleoperators and Virtual Environments*, vol. 1, no. 4, 1992, pp. 482–490, https://doi.org/10.1162/pres.1992.1.4.482.

Freeman, Jonathan, S. E. Avons, Don E. Pearson, et al. “Effects of sensory information and prior experience on direct subjective ratings of presence.” *Presence: Teleoperators and*

Virtual Environments, vol. 8, no. 1, Feb. 1999, pp. 1–13, https://doi.org/10.1162/105474699566017.

Freeman, Jonathan, S. E. Avons, Ray Meddis, et al. “Using behavioral realism to estimate presence: A study of the utility of postural responses to motion stimuli.” *Presence: Teleoperators and Virtual Environments*, vol. 9, no. 2, Apr. 2000, pp. 149–164, https://doi.org/10.1162/105474600566691.

Gallagher, S., & Zahavi, D. (2008). *The phenomenological mind: An introduction to philosophy of mind and cognitive science*. Routledge.

“Gamer Motivation Profile.” *Quantic Foundry*, apps.quanticfoundry.com/surveys/start/gamerprofile/. Accessed 12 Apr. 2024.

Georgiou, Yiannis, and Eleni A. Kyza. “The development and validation of the ARI questionnaire: An instrument for measuring immersion in location-based augmented reality settings.” *International Journal of Human-Computer Studies*, vol. 98, 2017, pp. 24–37, https://doi.org/10.1016/j.ijhcs.2016.09.014.

Heeter, Carrie. “Being There: The subjective experience of presence.” *Presence: Teleoperators and Virtual Environments*, vol. 1, no. 2, 1992, pp. 262–271, https://doi.org/10.1162/pres.1992.1.2.262.

Heidegger, M. (1962). *Being and time* (J. Macquarrie & E. Robinson, Trans.). Harper & Row. (Original work published 1927)

Heim, Michael. *The Metaphpysics of Virtual Reality*, Oxford University Press, Oxford, 1994, pp. 109–128.

Heinlein, Robert A. “Waldo.” *Astounding Magazine*, Aug. 1942.

Jennett, Charlene, et al. “Measuring and defining the experience of immersion in games.” *International Journal of Human-Computer Studies*, vol. 66, no. 9, 2008, pp. 641–661, https://doi.org/10.1016/j.ijhcs.2008.04.004.

Jäncke, Lutz. “Virtual reality and the role of the prefrontal cortex in adults and children.” *Frontiers in Neuroscience*, vol. 3, no. 1, May 2009, https://doi.org/10.3389/neuro.01.006.2009.

Kiili, Kristian, et al. “The design principles for flow experience in Educational Games.” *Procedia Computer Science*, vol. 15, 2012, pp. 78–91, https://doi.org/10.1016/j.procs.2012.10.060.

Kober, Silvia Erika, et al. “Cortical correlate of spatial presence in 2D and 3D Interactive Virtual Reality: An EEG study.” *International Journal of Psychophysiology*, vol. 83, no. 3, Mar. 2012, pp. 365–374, https://doi.org/10.1016/j.ijpsycho.2011.12.003.

Larijani, L. Casey. *The Virtual Reality Primer*. McGraw-Hill, 1994.

McMahan, Allison. “Immersion, Engagement and Presence.” *The Video Game Theory Reader*, edited by Bernard Perron and Wolf Mark J P., Routledge, New York, NY, 2009, pp. 67–86.

Merleau-Ponty, M. (1962). *Phenomenology of perception* (C. Smith, Trans.). Routledge & Kegan Paul. (Original work published 1945)

Michailidis, Lazaros, et al. “Flow and immersion in video games: The aftermath of a conceptual challenge.” *Frontiers in Psychology*, vol. 9, 2018, https://doi.org/10.3389/fpsyg.2018.01682.

Minsky, Marvin. “Telepresence.” *Omni*, 1980, pp. 45–52.

Murray, Janet Horowitz. *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. The MIT Press, 1998.

Ohmi, M. “Sensation of self-motion induced by real-world stimuli.” *Selection and Integration of Visual Information: Proceedings of the International Workshop on Advances in Research on Visual Cognition*, 1997, pp. 175–181.

Parkin, S. (2015, May 12). *Eve Online: How a virtual world went to the edge of apocalypse and back*. The Guardian. https://www.theguardian.com/technology/2015/may/12/how-virtual-world-edge-of-apocalypse-and-back-again

Pausch, Randy, et al. “Quantifying immersion in virtual reality.” *Proceedings of the 24th Annual Conference on Computer Graphics and Interactive Techniques - SIGGRAPH ’97*, 1997, https://doi.org/10.1145/258734.258744.

Perlin, K. “Can There Be a Form between a Game and a Story?” *First Person: New Media as Story, Performance, and Game*, edited by Noah Wardrip-Fruin and Pat Harrigan, MIT Press, Cambridge, MA, 2006.

Procci, K., and C. Bowers. “An examination of flow and immersion in games.” *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 55, no. 1, 2011, pp. 2183–2187, https://doi.org/10.1177/1071181311551455.

Prothero, Jerrold D. “The Role of Rest Frames in Vection, Presence, and Motion Sickness.” *University of Washington*, 1998. Available online: http://www.hitl.washington.edu/publications/r-98-11/

Quigley, L. (2015, February 20). *A day in Skyrim: An analysis of NPCs & storytelling in video games*. Medium – The Process. https://medium.com/the-process-collection/a-day-in-skyrim-an-analysis-of-npcs-storytelling-in-video-games-f64a023c7595

Reeves, Byron. “Being there”: Television as symbolic versus natural experience.” *Unpublished Manuscript, Institute for Communication Research, Stanford University, Stanford, CA* ., 1991.

“Remembering the Gates of Ahn’qiraj: Call of the Scarab - Wow.” *World of Warcraft*, Blizzard Entertainment, 20 Jan. 2022, worldofwarcraft.blizzard.com/en-us/news/20475665/remembering-the-gates-of-ahnqiraj-call-of-the-scarab.

Rheingold, H. L. *Virtual Reality*. Summit Books, 1991.

Rigby, Jacob M., et al. “Development of a questionnaire to measure immersion in video media.” *Proceedings of the 2019 ACM International Conference on Interactive Experiences for TV and Online Video*, 2019, https://doi.org/10.1145/3317697.3323361.

Sallnäs, E. L. “ Presence in multimodal interfaces.” *Proceedings of 2nd International Workshop on Presence, University of Essex, Colchester*, 1999. Available online: http://www.nada.kth.se/~evalotta/Presence/IWVP.html

Sanchez-Vives, Maria V., and Mel Slater. “From presence to consciousness through virtual reality.” *Nature Reviews Neuroscience*, vol. 6, no. 4, Apr. 2005, pp. 332–339, https://doi.org/10.1038/nrn1651.

Schütz, A. (1967). *The phenomenology of the social world* (G. Walsh & F. Lehnert, Trans.). Northwestern University Press. (Original work published 1932)

Sherman, William R., and Alan B. Craig. "Bringing the Virtual World to Life." *Understanding Virtual Reality: Interface, Application, and Design*, 2nd ed., Elsevier Science, San Diego, 2018, pp. 658–723.

Slater, Mel. "A note on presence terminology." *Presence Connect*, vol. 3, 2003, pp. 1–5.

Star Citizen - Chris Roberts Pitch Video, YouTube, 11 Oct. 2012, https://www.youtube.com/watch?v=VhsgiliheP0&ab_channel=IGN. Accessed 20 Nov. 2023.

Sutherland, Ivan E. "A head-mounted three dimensional display." *Proceedings of the December 9-11, 1968, Fall Joint Computer Conference*, vol. 33, 1968, pp. 757–764, https://doi.org/10.1145/1476589.1476686.

Sweetser, Penelope, and Peta Wyeth. "GameFlow: A model for evaluating player enjoyment in games." *Computers in Entertainment*, vol. 3, no. 3, 2005, pp. 3–3, https://doi.org/10.1145/1077246.1077253.

Tcha-Tokey, Katy, et al. "A questionnaire to measure the user experience in immersive virtual environments." *Proceedings of the 2016 Virtual Reality International Conference*, 2016, https://doi.org/10.1145/2927929.2927955.

Thon, Jan-Noël. "Immersion Revisited: On the Value of a Contested Concept." *Extending Experiences: Structure, Analysis and Design of Computer Game Player Experience*, edited by Olli Leino et al., Lapland University Press, Rovaniemi, 2008, pp. 29–43.

University of Silicon Valley. “How to Make Immersive Game Design.” *University of Silicon Valley*, 7 Dec. 2023, usv.edu/blog/how-to-make-immersive-game-design/.

“What Is Immersive Gaming?” *Arm*, www.arm.com/glossary/immersive-gaming#:~:text=Immersive%20games%20are%20video%20games,possible%20by%20cutting%2Dedge%20graphics. Accessed 14 June 2023.

Wiederhold, B K, et al. “The Effects of Immersiveness on Physiology.” *Virtual Environments in Clinical Psychology and Neuroscience*, edited by G Riva et al., IOS Press, Amsterdam, 1998.

Wirth, Werner, et al. “A process model of the formation of spatial presence experiences.” *Media Psychology*, vol. 9, no. 3, 2007, pp. 493–525, https://doi.org/10.1080/15213260701283079.

Witmer, Bob G., and Michael J. Singer. “Measuring presence in virtual environments: A presence questionnaire.” *Presence: Teleoperators and Virtual Environments*, vol. 7, no. 3, 1998, pp. 225–240, https://doi.org/10.1162/105474698565686.

Wloka, Matthias M. “Lag in multiprocessor virtual reality.” *Presence: Teleoperators and Virtual Environments*, vol. 4, no. 1, 1995, pp. 50–63, https://doi.org/10.1162/pres.1995.4.1.50.

Wrathall, M. (Ed.). (2025, January 31). Martin Heidegger. In *Stanford Encyclopedia of Philosophy*. Retrieved May 8, 2025, from https://plato.stanford.edu/entries/heidegger/

Zhang, Chenyan, et al. “Spatial immersion versus emotional immersion, which is more immersive?” *2017 Ninth International Conference on Quality of Multimedia Experience (QoMEX)*, 2017, https://doi.org/10.1109/qomex.2017.7965655.