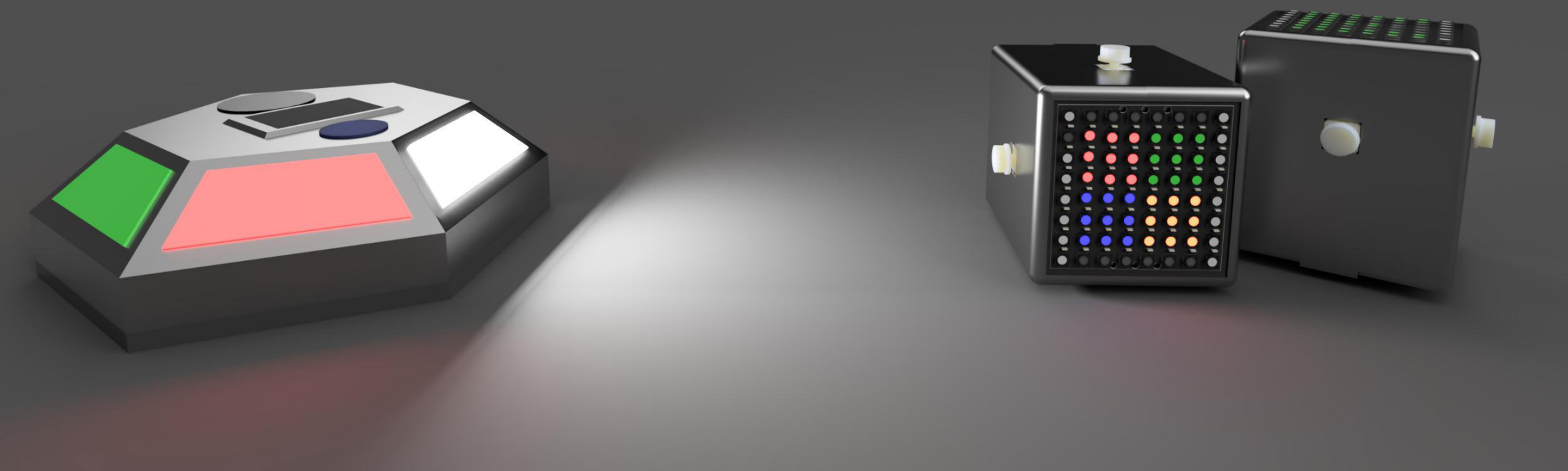
Hybrid Board Games with NFT Characteristics

The road to HYBRIDA

By: Madeleine Drougge, Mark Christensen & Marco Hvidberg



Title:	Hybrid Board Games with NFT Characteristics: The road to HYBRIDA
Semester:	Master Thesis
Project period:	February 2022 - June 2022
ECTS:	30
Supervisor:	Mikael B. Skov & Enrique Encinas
Project group:	cs-22-hci-10-17

Mark Marturin Christensen

Madeleine Johannesen Drougg

Marco Hvidberg-Olsen

Number printed:	103 Pages
Pages:	91 Pages
Appendix:	12 Page

Abstract

Board games have become increasingly popular over the last few years, with families and friends alike meeting for a fun and entertaining experience. It comes as no surprise that analog board games have in some cases expanded upon its features by integrating digital components, leading to the category of *hybrid board games* (HBGs), which utilizes the tangibility of physical game pieces and enhances them with digital features. This report seeks to conceptualize a connection between HBGs and the technology of Non-fungible tokens (NFTs). Specifically, identifying NFT characteristics that can be meaningfully implemented into HBGs to complement the overall play experience, while also learning what are favorable design choices for HBGs. Through research, as well as analysis of published board games and their digital counterparts, an understanding of the effects of dematerialization became apparent, such as loss of tangibility. With the knowledge gained, we constructed three technological probes, designed to be HBGs with NFT characteristics, which were investigated by conducting two workshops with participants. The analyzed data from these workshops were used to conceptualize our high-fidelity prototype, called HYBRIDA, which incorporated four main characteristics of NFTs that we believe to be favorable for integration in HBGs. HYBRIDA was evaluated by participants and from this analyzed data gathered from the evaluation, we conclude with our findings regarding NFT characteristics in relation to HBGs.

Summary

This master thesis explores the subject of *hybrid board games* with incorporated *Non-fungible token* (NFT) characteristics. Specifically, we seek to investigate which NFT characteristics can be implemented into hybrid board games in a meaningful way. Hybrid board games can be considered that of regular analog board games, which have been enhanced by combining them with computing technology. This gives the opportunity to add digital features and aesthetics to the game experience of board games, making it possible to strengthen some of the less engaging interactions, such as keeping check on game resources, while also introducing new ways to interact with the game board, or it interacting with you. Non-fungible tokens, also called NFTs, are crypto tokens that are especially useful for a number of things; proof of ownership and authenticity of digital assets, such as digital art; being dynamic due to *smart contracts*, essentially giving the opportunity to attach program code to the assets. To gain a deeper understanding of both *hybrid board games*, as well as NFT characteristics, we began researching previous studies surrounding the two topics. Afterwards, we analyzed a number of analog board games and their digital counterparts to see the advantages, as well as disadvantages, of board games that have been dematerialized . The knowledge gained up to this point is used to elicit a list of requirements for building a high-fidelity prototype of a hybrid board game with NFT characteristics, which is to be built later in the project. Afterwards, three technological probes were designed and constructed with focus on the NFT characteristics of; *ownership, transience, trading, upgradeability,* and *community* as well as general hybrid board game aspects, which we invited participants to explore by conducting two workshop sessions. The data gathered from the workshops were analyzed and used to narrow our scope and requirements further. The design process of the high-fidelity prototype was then initiated, which resulted in our *hybrid board game* prototype named HYBRIDA, which consists of a modular game board, a Game Hub and two Game Cubes. The game board can be switched out with another, changing the game type, while the Game Hub is placed in the middle of the game board, functioning as a game host. The Game Cubes are the main points of interaction for the players, as they use these to interact with the Game Hub to be able to build their personal NFT. This was followed by an evaluation, where participants were invited again to interact and play with HYBRIDA and afterwards give feedback of their experience. The data gathered from the evaluation were then analyzed and used as topics of discussion, and answering our research questions.

1. Introduction

Playing analog board games is an activity that has existed for centuries and has continued growing in popularity ever since, providing people with fun, entertaining, and educational experiences. With a market value estimated to reach 12 billion US dollars by 2023, the appreciation for analog board games has increased by almost 5 billion US dollars since 2017, making them more popular than ever [41]. As we apply the term, *analog board games* denote games where players engage with non-digital components on a playable surface. The sustained interest in analog board games evidently correlates with the rich social situations and tangible interactions associated with them. Nearly all analog board games support multiplayer applications and co-located players, encouraging people to organize social events with friends and family. These situations afford rich social interactions as people gather around a table, using face-to-face and gestural communication to collaborate and interpret game actions. Additionally, analog board games contain physical game pieces and boards that promote haptic feedback and tangible play. Tangible components embody physical shape, mass, texture, and temperature, making them pleasant to touch, hold, and move. With these characteristics, analog board games foster engaging interactions and immersive feelings during play; moving pawns on and around the game board, throwing dice, exchanging and hiding resources from other players, etc.

While analog board games support social and tangible affordances, digital games present many interesting features that augment old-fashioned gameplay. For example, digital games may utilize audial-visual aesthetics like video, audio, images, and graphics to strengthen their narrative and atmosphere. These aesthetics, coupled with feedforward and feedback regarding an action, facilitate player involvement and immersion into the digital game world. In addition, many digital games automate arduous and tedious tasks, such as bookkeeping and performing calculations, to make them more accessible and enjoyable to play. While the physical nature of analog board games may limit game content, digital games are tied to the creativity of the developers and their opportunity to build upon the existing software through continuing updates.

Recently, a new category within digital games, known as *crypto games*, has emerged. With more than 1.2 million new users across diverse game platforms in March 2022, the popularity of crypto games has increased by 2,000% since the first quarter of 2021 [20]. Crypto games commonly refer to *"[...] games that store tokens, e.g. in-game items, on a distributed ledger atop a cryptocurrency network."* [37]. In other words, games where players may utilize in-game items or rewards acquired while playing across multiple game platforms, marketplaces, and similar.

While traditional digital and analog games restrain players from using assets outside the boundaries of a game, crypto games enable this functionality through their underlying blockchain technology. However, there are many types of blockchains with distinct mechanics to support diverse game applications, yet as research suggests, most crypto games benefit from *non-fungible tokens* (NFTs) [26]. NFTs are based on the Ethereum blockchain and enable users to give digital, as well as physical, assets proof of authenticity and ownership [27]. While crypto games benefit from this technology, allowing players to own and customize in-game items, a few companies have begun exploring the opportunities of NFTs in analog board games. Based on this, and our previous work on NFT

technology within physical space [2], we believe that NFTs may provide opportunities for creating new board game experiences.

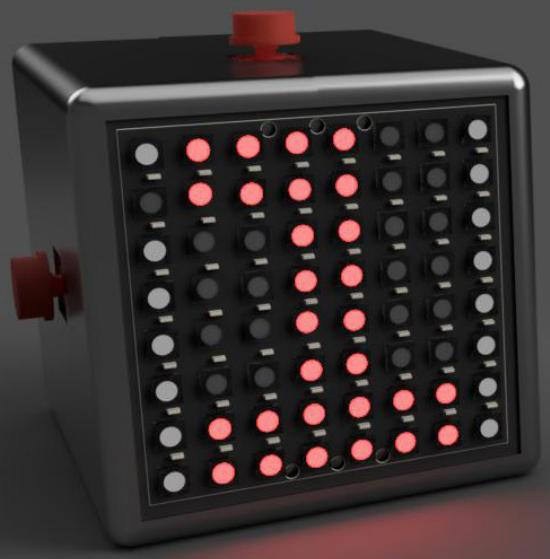
Based on the distinct advantages offered by analog and digital games like crypto games, recent HCI studies focus on combining computing technology with physical board games to bring forth new game experiences. With these hybrid versions, researchers aim to maintain the social situations and tangible play of analog board games, while implementing meaningful digital features and aesthetics. In this way, they seek to improve upon the weaker characteristics of each game category while promoting their rich properties. Explorations of hybrid board games include augmented tabletops [6, 18, 19, 25], interactive playing pieces [29, 33], mobile interactive surfaces [36], and a range of other approaches for developing HBGs [21, 24, 29, 40].

Although the work on hybrid board games and hybrid play is manifold within HCI research, we seek to explore a new direction by implementing NFT characteristics into analog board games. Crypto games also remain mostly unexplored within the game industry, particularly in analog board games, despite their increasing popularity [37]. Based on this, our project explores in what ways characteristics of NFT technology can act as interaction design material to create *hybrid board games*. In the context of this report, we characterize *interaction design material* as principles that practitioners may apply in designing interactions. In this research, hybrid board games (HBG) denote board games in which both tangible components and digital elements are required to enact play. This leads us to our two research questions:

"What Non-Fungible Token characteristics can be utilized as design material to create interactions?"

"How can we design a Hybrid Board Game with meaningful incorporation of Non-Fungible Token characteristics?"

In order to investigate said problem, we divide our project into 4 parts; Part 1 presents the *background* of this project, where we begin examining related work on hybrid board games, social play, and crypto games to understand the current state of our research area. Thereafter, we analyze digital and analog board game counterparts to grasp how dematerialization affects board game experiences. We summarize the findings of our background research and conclude Part 1 by eliciting requirements for developing a high-fidelity prototype. Part 2 introduces an *exploration of our design space*, wherein we produce three technological probes based on a set of design iterations. These probes are investigated with two expert groups in a participatory workshop to explore future design ideas and determine a direction to pursue. From the workshop findings, we iterate upon our pre-established requirements before presenting the selected ones. Part 3 concerns the *design and construction* of our high-fidelity prototype, named HYBRIDA. Lastly, P4 outlines the *findings* of this study and concludes our Master Thesis project. Herein, we describe the evaluation of HYBRIDA, including the results derived from it. These findings are used to discuss previous work within our research area, and to determine whether we have fulfilled our requirements and research questions.



Part 1: Background

Part 1 presents the background research made for our Master thesis project of investigating non-fungible tokens as design material in hybrid board games. The part contains three chapters, including: 2. Related work, 3. Unpacking Interactions in Analog and Digital Board Games, and 4. Eliciting Requirements. Through these chapters, we explain the current state of the chosen research area by presenting previous work on hybrid board games, social board game play, and play-to-earn games. With knowledge gained herein, we advance by analyzing analog and digital board games to obtain an improved understanding of the intersection between the two. Derived from these insights, we summarize the background research by eliciting requirements for developing a high-fidelity prototype.

2. Related Work

The following chapter presents previous work on *hybrid board games, social board game play*, and *Play-to-earn games* to describe the current state of the chosen research area. The goal with these sections is to investigate existing research to understand the implications and limitations of creating a hybrid board game, while incorporating NFT characteristics. We also wish to emphasize the need for additional research efforts on NFTs and blockchain technology within games, which is presently narrow within the field of Human-Computer Interaction (HCI). Based on this, we begin looking at hybrid board games to map their current applications and characteristics. Social play is then considered to understand how the implementation of digital elements in board games may affect the social intercourse of said game type. Lastly, we examine crypto games and their *play-to-earn* game models to comprehend the future possibilities of blockchain technology within the game industry. We do this, to investigate the ways in which NFT characteristics may augment hybrid board games.

2.1 Hybrid Board Games

Several studies have investigated the integration of novel technologies into board games, also known as *hybrid board games* (HBGs), and their abilities to enhance gameplay. This increased interest has offered new and innovative approaches for delivering content in otherwise non-digital board games. [40] propose six unique qualities for designing hybrid board game experiences, including *multimodal stimulation, real-world parameters, virtual attributes of physical artifacts, social-* and *haptic qualities*. [24] mentioned similar principles in their 17 design guidelines for hybrid board game creation, such as *tangibility, aesthetics, added value,* and *sociability*. While these guidelines are universal to support *"[...] a variety of other contexts and platforms [of hybridity]"* [24], Gómez-Maureira et al. [17] introduce taxonomic lenses for utilizing artificial intelligence (AI) in HBGs. The authors argue that AI-technology remains sparse in the area of HBGs and suggests five dimensions for developers to explore: *embodiment, gameplay, role, physical* and *temporal domain* [17]. Other studies also present guidelines on designing digital tools for usage in board game play [35] and dimensions of the hybrid design space [7, 43].

Another significant body of research has explored and examined hybrid board games in the form of stationary interactive surfaces, also known as *digital tabletops* [6, 18, 19, 25]. Magerkurth et al. [25] introduce the *STARS Platform*, an interactive game table with integrated sensing and interaction devices to support multiple types of inputs and outputs. Evaluating STARS under natural settings, they found that the participants enjoyed the richness and audial-visual aesthetics of the digital tabletop, despite using time adapting to the new game features presented. Similarly, Hartelius et al. [19] present *Tisch*, a digital tool for playing board games on a Microsoft Surface that focuses on preserving tangible and social interactions by allowing players to have more agency over game rules. Their findings showed that the participants appreciated the automation of bookkeeping tasks and the ability to play an HBG according to personal preferences. Meanwhile, Haller et al. [18] present ten heuristics for designing and evaluating digital tabletop games based on an analysis of prominent tabletop hardware technologies and their applications in research. Although digital tabletops can support the social affordances of analog board games, they suffer from high costs and portability issues [29, 35]. As such, researchers have examined the use of mobile applica-

tions, or *apps*, to extend and supplement gameplay. For example, Rogerson et al. [36] adopted a mixed-method approach in which they explored and classified the core functionalities enforced by apps in HBGs. Based on the study findings, the authors propose an HBG model that outlines eight roles of apps in supporting gameplay, including *teaching, calculating, remembering, storytelling, timing, randomizing, housekeeping,* and *informing*. Unlike broad guidelines [7, 24, 40, 43], this model provides a detailed overview of the current HBGs and their future possibilities, but is limited to mobile technology.

While most research examining HBGs focuses on augmenting board games with interactive flat surfaces and personal devices, Mora et al. [29] propose shifting the direction toward designing *interactive game pieces: "Embedding interactivity across multiple components opens up a wider space of possibility and a higher degree of flexibility in shaping the game experience."* [29]. They stress the lack of physical affordances in HBGs, otherwise present in the active use of traditional game pieces, and introduce a new design approach based on *tokens, constraints, spatial expressions,* and *interaction events*. By redesigning a game for training emergency workers, the authors find that the approach supports rich social affordances and engaging interactivity. Plijnaer et al. [33] use a similar method but focus on constructing *tangible digital tabletops*. They present a hybrid version of the well-known game *Dungeons and Dragons*, which implements a physical battle grid with lights to visualize gameplay. Their study showed that the tangible digital tabletop created new opportunities for storytelling and enhanced communication of game data.

As we learn from this abundance of research, hybrid board games come in many variations and what essentially differentiates them is the degree to which their digital and tangible elements are in play. Subsequently, the diverse HBG approaches promote distinct types of interactions and affordances during play. While both digital tabletops and interactive game pieces are physical in nature, the preceding integrates the digital part as the primary source for enacting play. Instead of utilizing the material richness of the physical world, digital tabletops replace tangible components with *GUI* (graphical user interface) elements and confine interactions to a touchscreen area. As a result, HBGs of this kind do not support the tangible interactions of analog board games despite being physical. With interactive game pieces, the focus remains on the tangible part of the HBG since the players physically engage with game components. Meanwhile, digital elements act as aesthetics to enrich the game narrative and provide additional feedback to the players. However, this variation of HBG may lessen the social situation of analog board games because most interactions happen through individual player tokens. Conversely, digital tabletops maintain a social setting as it provides a shared platform for all players to gather around and interact with. This issue of sociability also applies to HBG implementing personal devices, like mobile phones and associated apps, as the digital part. Even though using personal devices in board games may isolate the players, we understand that it depends on their integration in the gameplay.

2.2 Social Play in Hybrid Board Games

A substantial part of playing board games is the social intercourse that either happens naturally or through the board game design itself. While the majority of board games are collective in nature, embedding digital components may influence their inherent social play and hinder certain interactions. Accordingly, several studies investigate how to translate the social elements of analog board games into hybrid ones [24, 48]. Xu et al. [48] studied the social interaction of four different board games to inform the design of hybrid board games in the type of *tabletop handheld aug-*

mented reality (THAR). Based on the study findings, the authors suggest five categories of social interactions, including: 1) *Chores*; 2) *Reflection on gameplay;* 3) *Strategie;* 4) *Out-of-game;* and 5) *Game itself* [48]. They emphasize the importance of Chores, i.e., the interplay deriving from bookkeeping activities, to support player engagement and refrain practitioners from automating these game parts. Van Loen et al. [45] present the digital tabletop *Entertaible*, which focuses exclusively on sociability through its design. Compared to traditional digital interfaces, such as iPads and iPhones, Entertaible supports multiple concurrent inputs and allows players to interact with the game board simultaneously.

Researchers within the Digital Game Association have examined how digital elements can provide possibilities for social interactions in board games [16, 31]. Nummenmaaa and Kankainen [31] analyzed 13 hybrid board games to understand how current developers incorporate and support social features in this board game type. They classified seven key social aspects of HBGs, including: 1) having *a game master and/or common enemy;* 2) *replacing player managed parts with technology*; 3) *expanding possibilities for playing socially*, such as online play and randomization mechanics; 4) implementing digital elements to add *social features and interactions* beyond analog games; 5) using a *personal physical element as game interface*; 6) *hiding personal information*; and 7) encouraging *family play*. Eriksson et al. [16] introduce the characteristic of *social adaptability*, which refers to how a board game actively or passively adjusts to its social environment. To inherit this social feature, the authors present a set of initial guidelines for developing hybrid board games like supporting interruptibility, allowing multiple communication channels, and designing for external events.

As explained in Section 2.1, hybrid board games promote different levels of social interactions based on their designs. After examining work on social play in HBGs, we acquired a deeper understanding of what features encourage sociability. By applying this knowledge to the diverse HBG approaches, we understand that most HBGs provide social interactions through collocating players around a mutual playing space. Although tangible components stimulate sociability, interactive game pieces introduce continuous play as they allow players to engage with a personal token at any given time of play. This game structure isolates players from the social communication and interactions deriving from giving and receiving attention interchangeably. Contrarily, digital tabletops present turn-based play as touchscreens do not support simultaneous actions, creating attention around each player's turn and encouraging social conversations. However, as such surfaces digitize nearly all tangible components, several game tasks become automatic and many physical interactions are displaced. While automation can remove tedious tasks and promote enjoyable game experiences, it also lessens social interactions emerging from performing and discussing chores. For HBGs that implement personal devices, practitioners should also consider the degree of automation and continuous play.

2.3 Play-to-earn in Crypto Games

Crypto games have recently received substantial attention due to their *play-to-earn models* that combine the world of finance and games, enabling players to earn crypto or NFTs as they play. An example is the crypto game *CryptoKitties*, where players buy virtual cats with special attributes to collect and breed for the purpose of earning crypto [13]. This way of playing digital games has raised curiosity around the many possibilities of blockchain technology within the game industry [26, 38]. Min et al. [26] analyzed well-known blockchain games to map present integrations and predict future opportunities of the game type from a technological and commercial view. Their analysis revealed that the cur-

rent applications over-emphasized financial motives and lacked playability, while they benefited from implementing NFTs and system transparency. To undertake said issues, the authors propose exploring new uses of blockchain technology and mechanics to enrich game experiences. Serada et al. [38] explored the crypto game *CryptoKitties* to understand the importance of blockchain in shaping the future of game design and play. They found that three factors determined the value of crypto game tokens, including *limitation of blockchain scalability, demanding transactions*, and *anonymous ownership*.

While most research on crypto games focuses on the future opportunities of blockchain, a few studies have examined the drawbacks of implementing play-to-earn mechanics [37]. Scholten et al. [37] investigate crypto games in relation to gambling by comparing features of well-known Ethereum games against a set of legal and psychological gambling criteria. Their findings indicate similarities between crypto games and traditional gambling systems, particularly in terms of the chance-based mechanics, pay-to-win, and pay-for-completion setups that underlie these games. Conclusively, Scholten et al. [37] call for designers to apply gambling criteria to assist the development of future crypto games. Another study by Serada [39] provides similar findings after analyzing the crypto game Crypto Kitties, describing that the game supports gambling-like experiences due to its unpredictable gameplay. However, the author emphasizes that *Crypto Kitties* also implement strategic features like traditional games.

As we learn from this limited research on crypto games, the current applications have a negative focus as they encourage trading, gambling, and play-to-earn mechanisms. Yet, in spite of these financial motivations, the blockchain technology underlying crypto games show promising possibilities within the game industry if applied appropriately. As the abovementioned studies suggest, researchers should explore ways in which blockchain mechanics can enrich game content and narrative to provide new interactions and playful experiences. Specifically, they propose investigating NFTs and their use of smart contracts to create games, as this technology introduces interesting characteristics. These NFT characteristics include, among others, *asset ownership, asset reusability, system transparency,* and *user-generated content* [26].

3. Unpacking Interactions in Analog and Digital Board Games

Motivated by our learnings from previous work on hybrid and social board games in Chapter 2, we analyze analog and digital board games to study how *dematerialization* affects interactions, affordances, and experiences. According to Campenhout et al. [44], dematerialization is the process of tangible artifacts adopting digital characteristics and fading into virtual environments, such as music CDs and credit cards being replaced with MP3 files and digital payment apps. We apply the terminology of dematerialization to understand the intersection between digital and analog board games, seeking to design a HBG that properly balances physical and digital aspects. As such, we use the analysis findings to investigate HBG creation further and inform the elicitation of requirements for a HBG prototype that implements NFT characteristics. Concisely, the following chapter outlines the process of selecting board games for the analysis, our procedure, and analysis findings.

3.1 Selecting Board Games

To investigate how board game affordances and interactions change through dematerialization [44], we analyzed physical and digital counterparts of six different board games; adding up to a total of twelve games (Table 3.1). We selected games for the analysis by cross-referencing different board game blogs and websites (e.g., DiceBreaker.com, BoardGameQuest.com, and BoardGameGeek.com) using the keywords ‘most popular games’ and ‘well-known games’ as search prompts. During the search, we disregarded those board games with only an analog or digital version available, as our objective was to understand the effects of dematerialization on board games. With a list of more than 20 board games after the initial search, we removed those that we could not acquire without purchasing. Redundant game types were also considered and subsequently discounted if they had similar gameplay, such as Splendor and Jaipur. We retained two social deduction games, i.e. games where one player has a secret for the rest to find out [11], as they focused on distinct types of social interaction; in One Night Ultimate Werewolf, players use verbal communication, while The Mind only allows bodily gestures. This narrowed the selection to six board games: Clever, The Mind, Splendor, One Night Ultimate Werewolf (ONUW), Codenames, and Catan. An overview of the final list of analog and digital board games is presented in Table 3.1.

3.2 Procedure

The analysis procedure involved three overall steps, as we elaborate on in the following section: 1) to play the analog and digital counterpart of one board game; 2) compare their differences in relation to dematerialization and its effects on the game experience, and; 3) classify common data themes. We applied steps 1 and 2 for each of the six board games before moving to step 3, which was the very last part of the analysis.

Before starting with the first step of the analysis, we discussed the order in which to play the twelve board games. Here, we decided to begin playing the undemanding board games within the chosen selection and proceeded with the more advanced games accordingly, following the order presented in Table 3.1. The level of difficulty was determined based on

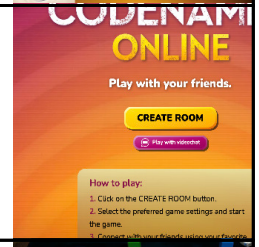
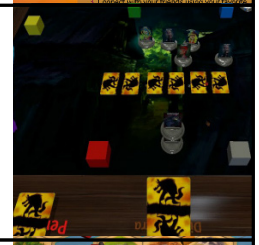
Name	Physical counterpart		Digital counterpart	
Clever	The aim is to make the best Clever point combinations by rolling six physical dice and checking off matching fields on a related paper scoreboard.		An digital application where all interaction occurs through the computer screen and keyboard, or the mobile phone. Singlemode, where the player competes against an AI, is the only available game mode. The player also receives help with calculations.	
The Mind	The aim of the game is to put the play cards in ascending order without exchanging any information with other players.		An digital application where all interaction occurs through the computer screen and keyboard, or the mobile phone. The players are not able to see each other.	
Codenames	The aim is to guess what cards belong to your team based on clues from the spymaster, but without picking the assassin card.		An online browser game where the interaction occurs through the computer screen and keyboard. The players also have an option to interact through a video chat.	
One Night Ultimate Werewolf	The aim is to find out which player received the secret role of being a werewolf and kill that person.		An online browser game where the interaction occurs through the computer screen and keyboard. The players may also use third-party software to be able to see each other.	
Catan	The aim is to achieve 10 points by building physical villages and cities through trading physical cards and using resources.		A desktop application game where all interaction occurs through the computer screen and keyboard. Single-mode, where the player competes against an AI, is also available.	
Splendor	The aim is to achieve 15 points by strategically purchasing physical cards with resources or physical game tokens.		An desktop application game where the interaction occurs through the computer screen and keyboard.	

Table 3.1: *The final selection of board games, including a description of their physical and digital counterparts.*

the group members' familiarity with the board games and their games' suggested age group. We chose this order to mitigate the process of learning the complicated rules and instructions of the more advanced board games. The games' level of difficulty also had a say in the number of rounds played. While we quickly grasped the gameplay and interactions of the undemanding board games after three completed rounds, the advanced ones required about five to seven rounds of play due to their intricateness.

In the first step, we started out by playing the analog version of *Clever* and explored its digital counterpart thereafter, as it was considered the least demanding board game. This order allowed us to understand the interactions and affordances of the original board game before investigating the new features of the digital version. After taking one turn each, we paused the game and shared initial thoughts or other remarks about the analog counterpart. These comments were noted in a separate document and involved, for example, Clever's strategic use of colors and confusing score sheets. Keeping these remarks in mind, we continued playing two additional rounds before stopping the game again. Now, discussing the analog counterpart in more elaborated details as we had acquired a deeper understanding of the gameplay. We then applied the same procedure to the digital version of *Clever*, wherein each group member downloaded the associated app before beginning to play. As the digital counterpart did not support multiplayer, except for AI-supported, we played three rounds individually on our personal devices. As an addition to the first step, we also regarded customer ratings and comments to ensure that no crucial aspects were unobserved after playing the board games. If we found any significant remarks, these issues were tested and subsequently discussed. For example, a player commented about *Clever* in the App Store that they had issues undoing a move after tapping incorrectly on the small mobile screen. This concern was investigated by all group members and proven correct, hence, documented with the remaining notes.

Moving to the second step, we compared the notes of each game version of *Clever* to investigate how dematerialization impacts interactions, affordances, and hence, the game experiences of the analog board game. This comparison consisted of taking one comment about the analog counterpart from the document and then looking for similarities or dissimilarities in the notes concerning the digital counterpart. From this, new considerations of the effects of dematerialization emerged, which we put in a new document section.

In the third step, we organized our reflections and comments about the twelve board games into a collective document to keep an overview. To arrange this considerable amount of data into smaller groupings, *affinity diagramming* was used [32]. As explained by Plain [32], affinity diagrams are an efficient method for organizing large pieces of information into manageable categories using only sticky notes and an empty surface. In accordance with the method procedure, we transferred the discussion points from the document and wrote them on sticky notes. Then, we arranged the sticky notes on the surface by comparing them, putting those with similar topics together and the dissimilar in new groups. This process continued until all notes were placed in a grouping of related themes, issues, or ideas.

The affinity diagram resulted in six categories, as presented in Figure 3.1: 1) *tangible interaction*, 2) *availability*, 3) *commercial aspects*, 4) *social interaction*, 5) *automation*, and 6) *others*, and four subcategories: *intangible, tangible, reduced sociability,* and *increased sociability*. We unfold these in the following subsection and provide specific examples from the board game analysis.

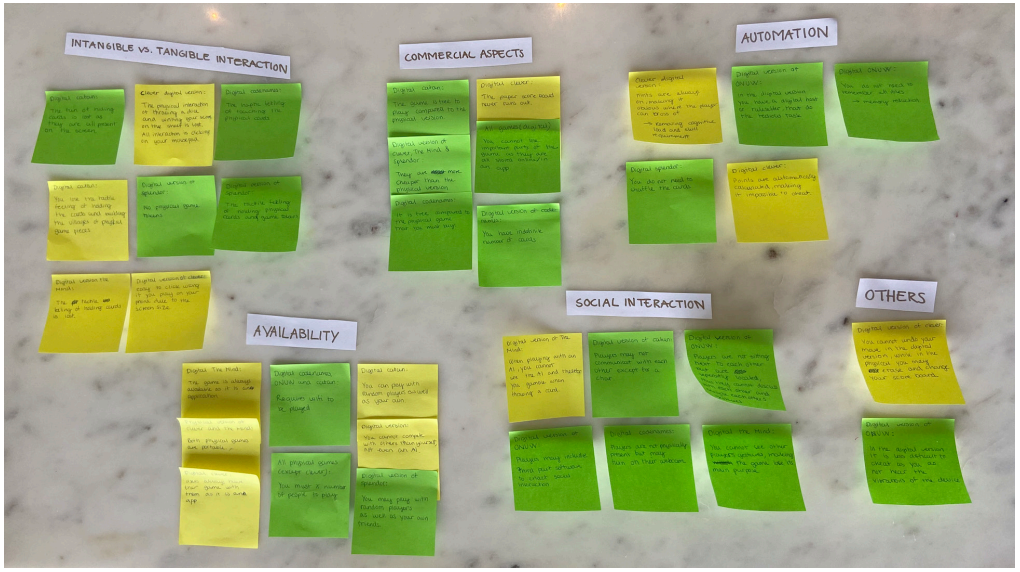


Figure 3.2: *An overview of the affinity diagram from the board game analysis.*

3.3 Analysis Findings

The analysis uncovered six overall themes or *characteristics* about dematerialization of analog board games (see Table 3.2). The grouping *Tangible vs. intangible interaction* concerns how board games have diverse degrees of tangible and haptic affordances. We regard two subcategories within this topic, *tangible and intangible*. *Availability* relates to how board games utilize diverse types of digital technology to enhance accessibility. *Commercial aspects* revolve around how digital board games, compared to physical ones, provide advantages for the customer in terms of financial cost. *Automation* involves how board games automate various tasks to reduce the players' cognitive load when playing. *Social interaction* concerns how board games promote various levels of sociability, which we divide into *reduced sociability* and *increased sociability*. Lastly, we put the remaining notes in a separate category named others. Table 3.2 summarizes the analysis findings and describes whether the analog and/or digital counterparts of all six board games obtained said characteristics. We use the indicators "*analog*" to signify the analog versions and "*digital*" for the digital versions, while an empty cell indicates that neither of the board game counterparts introduce the characteristic.

3.3.1 Intangible vs. Tangible Interaction

One of the common denominators in our findings was the lack of physical affordances and tangible interactions in the digital counterparts, which impacted the richness of playing the games. By *richness* in the context of board games, we refer to the quality of continuously involving, entertaining and engaging players in the game through diverse interactions. As we observed, when board games dematerialize into digital games, the physical game area and game pieces (e.g. cards, pawns, and dice) are replaced with virtual objects and mediated by interactive screens. Correspondingly, *point-and-click, drag-and-drop*, and *touch* interactions take over the physical manipulation of game pieces, like in Clever and Catan, where the tangible action of rolling dice is implemented as button clicks. Another example is the digital representation of resource cards in *The Mind, Splendor, ONUW,* and *Catan*, which removes the players' haptic feeling of holding and shuffling physical cards. The analog version of *Codenames* is not as tangible, with the only tangible interaction being to prepare the setup of physical game cards. On that account, there was no significant difference between playing the digital and analog counterparts in relation to this issue. As this indicates, dematerialization deprives analog board games of important tangible interactions and haptic feedback that usually provides material richness and engaging play.

Name	Tangible vs. Intangible iteraction		Availability	Commercial aspects	Automation	Social interaction	
	Tangible	*Intangible*				*Increased*	*Reduced*
Clever	Analog	Digital	Analog/Digital	Digital	Digital	Analog	Digital
The Mind	Analog	Digital	Digital	Digital		Analog	Digital
Codenames	Analog	Digital	Digital	Digital		Analog	Digital
One Night Ultimate Werewolf (ONUW)	Analog	Digital	Digital	Digital	Digital	Analog	Digital
Catan	Analog	Digital	Digital	Digital		Analog	Digital
Splendor	Analog	Digital	Digital	Digital		Analog	Digital

Table 3.2: *An overview of the findings from analyzing the dematerialization*

Intangible interaction can also constrain board game features and reduce the players' span of possible actions, impacting the natural creativity and imagination of playing board games. For example, in the analog version of *Catan*, players may hide their resource cards as a strategy to confuse the other players and act as they are far behind in the game. The digital counterpart, on the contrary, allows players to access their competitor's resources while they have no options to prevent it. A second example is that intangible play limits the players from physically manipulating other players' game artifacts, like stealing resource cards from someone's deck in *Catan* or taking a dice from the jackpot plate in *Clever*. Digital devices, such as smartphones or computers, also restrain players from carrying out simultaneous actions as they are not designed for multiple users interacting with them at the same time. This creates a turn-based structure and disrupts the traditional board game dynamics. As our considerations suggest, intangibility transfers the control of the board game from the players to the digital devices, whereas tangible interaction facilitates game creativity and supports additional actions.

3.3.2 Availability

Another denominator in our findings was the increased availability in the digital counterparts, compared to the analog ones, due to their use of diverse technologies. To play the analog board games, we were required to own the game setup and have all players physically present, while the digital board games could be played at any given time and context. For example, *Clever, The Mind, Splendor,* and *Catan* are desktop and mobile applications that players can download and play from their personal devices. Similarly, players can access *Codenames* and *ONUW* through the browser, but they require the device to have a wifi connection. Additionally, as the digital counterparts are stored on a device or in the browser, essential game artifacts cannot disappear and hinder the players from playing. As this suggests, digital board games are always accessible for players as long as they have the required digital platform. Moreover, a few digital counterparts supported different game modes, such as *randomized* or *AI competitors*. For instance, *Clever, The Mind*, and *Catan* have the option of *single-mode*, which allows players to compete against an AI if their friends are not available. The analog version of Clever also enables this, making it the only analog one, as players can practice throwing dice to create point combinations by themselves. Based on this, we also see that digital board games are accessible regardless of the player having anyone to play with, which is not the case with most analog games.

3.3.3 Commercial Benefits

The board game analysis also uncovered differences in commercial aspects between the analog and digital counterparts. While the analog board games cost 100 Danish kroner and above, their digital versions were free and open-source. *Clever, The Mind*, and *Splendor* were the only exceptions as they were priced at about 30 kroner each. In addition, we discovered that a pair of the analog counterparts may require players to buy additional game pieces, whereas this is only an option in the digital ones. For example, in *Clever*, players can run out of physical score sheets necessary for playing the game. Even though we are not developing a prototype for commercial purposes, these issues are interesting to consider.

3.3.4 Automation of Tedious Tasks

Another recurring theme was how several digital counterparts automated tedious game tasks to reduce the players' cognitive load when playing.

In *ONUW*, the associated application reads aloud the game instructions and roles instead of the players themselves, acting as a digital game host. Based on this, players do not need to remember any of the 18 roles (except for their own) or the specific order of when each role is to awaken, removing their memory load. Another example is *Clever*, where the application performs calculations after each dice roll to help the players compute the correct point combinations. This functionality reduces the cognitive skill requirement of multiplying numbers, meanwhile limiting the chances of players cheating or performing mistakes. In addition, *Clever* provides hints based on its calculations, indicating in what fields the players can mark their clever point combinations. Even though these hints remove cognitive load, they also take away the satisfaction of looking for fields to cross out. As these examples suggest, automating game parts can lessen cognitive tasks, mistakes, cheating, and other errors otherwise provided in analog board games. Yet, too much automation can diminish the enjoyment and immersion in the game.

3.3.5 Social Interaction

Another common issue was how dematerialization reduced social interactions in the digital board games, which facilitated more isolated and singular game experiences. The physical counterparts focused on collocated players and face-to-face communication, whereas the digital ones utilized screen-mediation and remote player locations. A crucial part of most board games is the social intercourse that occurs from sitting around a playable surface that affords face-to-face and gestural communication. However, when board games are digital, players become isolated behind their personal devices and the screen mediates all social interaction. For example, the *Clever* app removes all social intercourse as the only option is to play with single-mode. A few of the digital counterparts provide options to replicate social interactions, such as allowing players to turn on their webcam in *Codenames*, having virtual characters in *Catan*, or using third-party software in *ONUW*. Although multimedia and graphics promote social experiences in virtual game environments they cannot replace face-to-face communication, as the physical presence conveys a unique experience.

3.3.6 Others

After comparing all sticky notes, we had two remaining ones that did not qualify in any existing grouping nor related to each other. Therefore, instead of creating a separate group for each, we grouped them under the title *Others*. The first sticky note concerned how the *Clever* application restricts players from undoing a move after crossing out a field on the digital score sheet. Meanwhile, the analog version comes with pencils and erasers that allow players to regret what they have written. As we experienced, the lack of said app functionality creates frustrations and annoyance, especially when tapping wrong on the screen. The second sticky note addressed how the analog game setup of *ONUW* unintentionally encourages cheating. At the beginning of the game, the players blindly move cards around the game area based on the role given. This activity can reveal the secret identity of the diverse players due to the noises and vibrations coming from sending cards to each other. In the digital version, the app presents the identity cards of each player, hindering said issue from occurring.

The analysis findings of this chapter and the learnings from Chapter 2 provide a solid base from which we can elicit requirements for our high fidelity HBG prototype. As such, the following chapter summarizes our background knowledge by presenting a stable set of requirements.

4. Eliciting Requirements

Informed by the background knowledge obtained in the two previous chapters, Chapter 4 presents the first iteration of eliciting requirements for prototyping a hybrid board game that incorporates NFT characteristics. As stressed by Preece et al. [34], establishing requirements is an iterative process in which requirements evolve through a series of informing and refining activities. On that account, we will continue refining this first version of the requirements as we acquire new insights along our design process. In the following sections, we briefly explain the method used to specify and prioritize the requirements before providing a presentation of each.

4.1 Method

According to Preece et al. [34], a requirement is "*a statement about an intended product that specifies what it should do or how it should perform.*" As such, an essential part of eliciting requirements for the HBG prototype was understanding the conditions under which the users are to play with it [34], including limitations of existing experimental and commercial products. To achieve this, we combined two data-gathering techniques, *studying previous work* and *researching existing products*, as described in Chapter 2 and 3 respectively. By applying more than one technique, we seeked to achieve several perspectives of the research area, as emphasized in [34].

We organized the findings from studying related work (Chapter 2) and analyzing board games (Chapter 3) into one shared document. This provided an overview of the collected data, which simplified the process of identifying overlapping and irrelevant aspects. After inspecting the document and removing any unnecessary data, we used the remaining information to create a list of 23 requirements. These requirements were then classified according to their functionality or type of system constraint, giving a total of three overall categories: *functional, non-functional,* and *NFT-related requirements*. Specifically, we categorized eight requirements as functional, seven as non-function and eight as NFT-related.

To further organize the requirements within their given category, we applied the *MoSCoW* method to prioritize their importance according to the establishment of our high-fidelity HGB prototype [42]. The MoSCoW acronym denotes four classifications: 1) *Must have*, those requirements that the product cannot manage without; 2) *Should have*, those requirements that are not critical for product launch but of great importance to the users; 3) *Could have*, those requirements that provide additional value to the product, and 4) *Won't have*, those requirements that are not integrated in the current product but considered in future releases [42]. When we consider these classifications it is from the basis of a future prototype rather than a commercial product, as the abovementioned descriptions suggest. The prioritization consisted of taking one requirement at a time and discussing its significance for our hybrid board game, including the efforts required to implement the feature. For example, if we found a functionality essential for the HGB to properly operate, we would prioritize it as a Must Have requirement, while a fun but unrequired add-on would classify as a Could Have. This process resulted in classifying nine Must Have, ten Should Have, and four Could Have requirements.

4.2 Presentation of Initial Requirements

The following section presents the three categories in which we organized our requirements, including functional, non-functional, and NFT-related. Specifically, we explain what the requirement categories involve and provide elaborated descriptions of each requirement within. At the end of each subsection, we summarize the requirement category in a separate table that contains three descriptive columns: 1) *requirement ID*, which we use as reference points for the requirements throughout the report; 2) *requirement description*, which provides a short summary of the individual requirement, and 3) *prioritization*, which reflects the criticality of the requirement according to the MoSCoW method [42].

4.2.1 Functional Requirements

The eight functional requirements, presented in Table 4.1, relate to the range of operations the HGB prototype should perform. In other words, they reflect what functions the HBG needs to implement to serve the purpose of deliberately incorporating NFT characteristics to create new experiences with analog board games. We refer to their requirement ID as "F.X", where the "F" stands for *functional* and the "X" signifies its *placement* in Table 4.1.

Must Have

The three Must Have of our functional requirements revolve around utilizing digital mechanics to support interaction between players and the HBG, provide the players with adequate feedback, and encourage game immersion: (F.1) The first Must Have specifies that the HBG must recognize the individual players and communicate with them through speech or text to enable player-HBG interaction. (F.2) The second Must Have implies that the HBG must provide the user with feedback to indicate that their action or move is registered. (F.3) While, the third Must Have stated that the HBG must integrate appropriate digital aesthetics, such as graphics, sounds, and lights, to enrich the play environment and encourage immersion during game time.

Should Have

Five of the functional requirements are prioritized as Should Have and relates to aspects of accessibility and automation of game tasks: (F.4) The first Should Have outlines that the physical HBG setup should enable players to continue playing despite technical errors occurring. (F.5) The second Should Have specified that the HBG setup should not have complicated construction and hinder the players from starting to play. (F.6) The third Should Have concerns that the HBG should automate tedious tasks which require high amounts of cognitive loads, such as performing calculations and keeping track of scores. (F.7) The fourth Should Have implies that the HBG should automatically save the player's state during game time to support upgradable NFTs and transient game sessions. (F.8) The fifth Should Have and last functional requirement entails that HBG should automatically save the state of the game board, such as the placement of tokens, in case of interruptions, breaks, or errors.

ID	Functional Requirements	Prioritization
F.1	Support interaction between player and hybrid board game	Must have
F.2	Provide meaningful feedback to the players about the state of the game	Must have
F.3	Utilize digital aesthetics to enrich the gameplay	Must have
F.4	Allow players to continue playing if technology fails	Should have
F.5	Provide clear instructions on how to set up the HBG	Should have
F.6	Automation cognitive-demanding tasks	Should have
F.7	Automatic and continuous tracking of user progression	Should have
F.8	Automatic and continuous tracking of game state	Should have

Table 4.1: *An overview of the first iteration of functional requirements.*

4.2.2 Non-functional requirements

Our seven non-functional requirements, viewed in Table 4.2, specify the constraints which affect how the hybrid board game should perform operations, including its design attributes. Similar to the functional requirements, we use "NF.X" as ID reference, where "NF" denotes *non-functional* and "X" refers to the requirement's position in table 4.2.

Must Have

The three Must Have among the non-functional requirements deal with the implementation of digital elements and the types of interactions the HBG prototype must afford. (NF.1) The first Must Have specifies that the implementation of digital features must not be intrusive, but provide meaningful purpose to ensure tangible play. (NF.2) The second Must Have states that the HBG must support tangible interactions, such as physical game tokens and dice, and not replace these with interface elements. (NF.3) The third Must Have entails that the HBG must enable face-to-face and gestural communication between players to encourage social interactions.

Should Have

The next three non-functional requirements are Should Have and relates to automation, physical aesthetics, and accessibility of the HBG. (NF.4) The first Should Have implies that the level of automation, referred to in requirements F.6-F.8, should not eliminate social or tangible interactions. (NF.5) The second Should Have describes that the HBG must hide insignificant electronic components to avoid confusion and maintain the aesthetics of analog board games. (NF.6) The third Should Have states that the game area should be in a visible size for every player to view, reach, and analyze during game time.

Could Have

The last and only Could Have of the non-functional requirements relates to the availability of the HBG. Specifically, (NF.7) outlines that the HBG size and design could allow the players to quickly pack up and bring it to a new social event.

ID	Functional Requirements	Prioritization
NF.1	Provide meaningful digital implementation to ensure tangibility	Must have
NF.2	Utilize tangible interaction to enrich game experiences	Must have
NF.3	Enable face-to-face and gestural social interaction	Must have
NF.4	Provide enjoyable level of automation	Should have
NF.5	Hide confusing and non-essential electronic components	Should have
NF.6	Game area visibility	Should have
NF.7	Portable design	Could have

Table 4.2: *An overview of the first iteration of non-functional requirements.*

4.2.3 NFT-related Requirements

Lastly, the eight NFT-related requirements, displayed in Table 4.3, present the essential characteristics of NFT technology in which the HBG should integrate. They also include design implications on how to implement these technical dynamics. As with the two previous requirement categories, we apply the ID of "NFT.X", where "NFT" is an abbreviation for *NFT-related* and the "X" refers to the placement within Table 4.3.

Must Have

The three Must Have of our NFT-related requirements are related to essential characteristics of NFT technology. (NFT.1) The first Must Have implies that the HBG must implement *transient* functionalities to allow players to compete with their NFTs across different social settings and game types. By transient, we refer to the term "asset reusability" introduced by [26], which is the quality of elements being applicable in different contexts, such as using an in-game character across game platforms. (NFT.2) The second Must Have specifies that the HBG must support *upgradability* of NFTs, which refers to the functionality of allowing NFT-owners to customize their tokens. This requirement relates to the aspect of "user-generated content" [26], but is limited to adjusting already minted and created NFTs. (NFT.3) The third Must Have involves that the HBG must invoke a feeling of ownership towards in-game assets [26].

Should Have

The two Should Have among the NFT-related requirements also revolve around common features of NFT technology, particularly aspects of play-to-earn and community. (NFT.4) The first Should Have concerns that the HBG should utilize *play-to-earn* mechanics, as introduced in Chapter 2, in new ways that encourage fun and sociability rather than financial gain. (NFT.5) The second Should Have outlines that the HBG should provide a way of sharing NFTs associated with the game to support sociability and engagement in NFT communities.

Could Have

The three last NFT-related requirements are Could Have and deal with the implementation of trading mechanics. (NFT.6) The first Could Have describes that in-game transactions of NFTs could be quick and easy to avoid non-game-associated events taking away the attention of the

game. Requirement NFT.6 also applies to transactions occurring after time of play but is not as crucial at this time. (NFT.7) The second Could Have expresses that the HBG could have an associated but separate trading system for players to trade their NFT tokens or in-game features. (NFT.8) The third Could Have states that the trading functions of the HBG could encourage strategic and sentimental motives rather than financial ones.

ID	Functional Requirements	Prioritization
F.1	Implement transient features	Must have
F.2	Enable upgradability of NFT game components	Must have
F.3	Evoke sense of ownership towards assets	Must have
F.4	Avoid negative play-to-earn mechanics	Should have
F.5	Shareability in community	Should have
F.6	Ensure smooth trading transactions	Could have
F.7	Incorporate a transaction system to support trading	Could have
F.8	Encourage non-financial trading tendencies	Could have

Table 4.3: *An overview of the first iteration of NFT-related requirements.*

Part 2: Exploration of Design Space

Part 2 is an exploration of our design space, wherein we investigate how characteristics of non-fungible tokens may act as design material in hybrid board games. This part comprises three chapters: 5. Designing Three Technology Probes: Ludo Brawl, Trivia Brawl, and NFTs against Reality, 6. NFT Board Game Workshop: An Exploration and Evaluation with Technological Probes, and 7. Designing the Final Hybrid Game. We enact this by creating three technology probes that we further explore and examine in a participatory workshop with two expert groups. The findings acquired from the workshop are used to specify our design direction further and revise the first iteration of requirements.

5. Designing Technology Probes: Ludo Brawl, Trivia Brawl, and NFTs against Reality

In the following chapter, we outline the process of designing and implementing three technology probes of different hybrid board games, named *Ludo Brawl, Trivia Brawl,* and *NFTs against Reality*. According to Hutchinson et al. [21], a technology probe resembles a prototype but is different in terms of five features, including *functionality, flexibility, usability, time of use,* and *data logging*. They are open-ended, simple technologies designed to encourage reflection on pre-existing ideas and inspire future design concepts rather than early versions of products under development [21]. Even though our technology probes do not consist of any electronic components, we simulate their functions through a "wizard of oz"-inspired approach during play [34] and implement the four remaining features. Pertaining to this, the aim of constructing our probes is to use them as tools in a participatory workshop to explore how NFTs act as Interaction Design material in hybrid board games. Specifically, we seek to collect three types of data: the use of the probes themselves, the relationship between the players, and the application of NFT characteristics in designing new board game experiences. We use this data to iterate upon our requirements and inform the establishment of an upcoming HBG prototype.

5.1 Design Process

Informed by the first version of requirements presented in Chapter 4, we began sketching design ideas for the technology probes. To avoid constraining our creative processes in early design phases, we decided that it was optional to include all 23 requirements in the design concepts, but that we should focus on the Must Have as they are essential. The requirements were also in their initial stage and under development, meaning they would not all necessarily be a part of the final selection of requirements. Moreover, we agreed on drawing sketches rooted in well-known analog board games, attempting to make the probes easy to explain and understand when introduced to the workshop participants. This would also challenge the participants' views on existing board games and facilitate experimentation about the implementation of NFTs in analog board games, which reflects the very purpose of technology probes. Lastly, the design ideas had to include two or more of the following NFT characteristics, which are also represented through our NFT-related requirements:

1. *Ownership*, which refers to blockchain technology enabling users to create and obtain possession of any asset, but often things perceived as valuable or meaningful to users.

2. *Transient*, which involves decentralized storages that make it possible to utilize NFTs across multiple platforms and contexts.

3. *Upgradability,* which is a function that allows users to edit and continue developing an NFTs.

4. *Trading,* which concerns that users decide the value of NFTs and may sell it to that price on any associated marketplace.

5. *Community,* which refers to the important peer-to-peer mechanisms and social connectedness that surrounds the crypto world.

We conducted a total of three design iterations before deciding upon three concepts of hybrid board games: *Ludo Brawl, Trivia Brawl,* and *NFTs Against Reality*. *Design iterations*, as we use the term in this report, refer to the process of continuously improving and refining design ideas based on feedback. Based on this, each iteration was a process of sketching HBG design ideas individually and presenting them in a design critique session to receive feedback from the other project members.

The first design iteration focused on generating as many sketches as possible to widen the scope of potential directions to pursue. This resulted in seven design concepts that drew inspiration from well-known board games like *Ludo, Snakes and Ladder,* and *Cards against Humanity*. Each group member presented their sketches during the design critique, explaining the gameplay and implementation of NFT characteristics and requirements. After discussing each idea, a pair of new considerations emerged as we were unsatisfied with the digitalization of game cards and the complicated use of NFT characteristics. Based on these, we determined to perform a second iteration.

The second design iteration revolved around exploring entirely new design concepts and refining existing ideas as we felt inspired. This led to a total of five sketches, where three of them presented new ideas and two focused on previous ones. In the second iteration, the design ideas were more creative and elaborate yet the implementation of NFT technology was simplified. After the second design critique, we felt secure about three design concepts and decided to move on with *Ludo Brawl, Trivia Brawl,* and *NFTs Against Reality*. However, as we were not completely satisfied with the details of each idea, we carried out another iteration.

The third design iteration aimed to refine the three previously mentioned design concepts. Instead of considering refinements individually, we performed the activity collectively to ensure that all group members had the same understanding of how the probes should be built and played. The succeeding sections provide detailed descriptions of each technology probe; *Ludo Brawl, Trivia Brawl*, and *NFT against Reality.*

5.2 Ludo Brawl

Ludo Brawl is an NFT-based game that draws inspiration from the classic board game *Ludo* [46]. The game is played by two to four players, in which they compete with their personal NFT player token to reach the center of the board without *downgrading it*. Unlike the original Ludo game, Ludo Brawl utilizes characteristics of NFT technology to facilitate immersive experiences and enrich the otherwise simple board game. Specifically, we wanted Ludo Brawl to challenge pre-existing views on Ludo by implementing the following three characteristics: 1) *ownership*, 2) *transience* and 3) *upgradability*. To investigate the principle of *ownership in board games*, each player is given a personal player token that represents their personal NFT. We explore *transience* by allowing the players to keep their player token across every game session regardless of context or game type. Lastly, *upgradability* is examined by different functionalities of achieving and losing aesthetic features of one's player token. In other words, the players may upgrade their player token by gaining LEGO bricks and using these to create different shapes and looks. We elaborate on these three characteristics in the following subsections.

5.2.1 Components and Implementation

Ludo Brawl is composed of two parts; the NFT player tokens and the tabletop itself, including a die that acts as the control variable (Figure 5.1). We built the game board out of cardboard and used blue, green, red, and yellow markers to visualize the surface according to the traditional layout of Ludo. Four new board fields were also added to enable *upgradability*, as illustrated in Figure 5.1: (1) a jackpot plate, (2) “VS.”, (3) “-1”, and (4) “+1”. Each player token was made of four LEGO bricks to support easy *upgradeability*, meanwhile encouraging creative freedom and experimentation during time of play [(Hutchinson et al., 2003)].

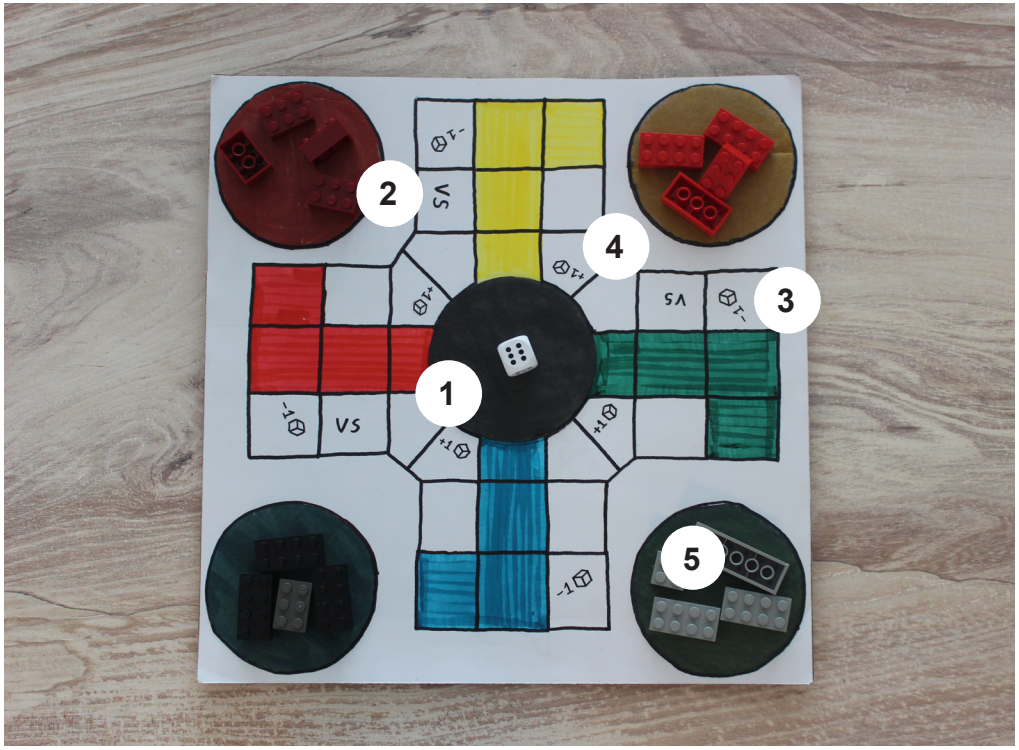


Figure 5.1: *The different components of Ludo Brawl.*

5.2.2 Preparing to Play

To set up Ludo Brawl, the tabletop is placed in the middle of all players with four LEGO bricks put in each home, as viewed as (5) in Figure 5.1. Before play, each player chooses one of the available homes and assembles their token using the given bricks (Figure 5.2). The token represents a personal NFT or character that the players may use in this and subsequent games of Ludo Brawl, Trivia Brawl, or similar. In the case of owning an NFT player token beforehand, the player competes with this instead.

Figure 5.2: *The players prepare for gameplay by assembling their NFT character.*

5.2.3 Gameplay

The gameplay of Ludo Brawl works much like the original Ludo, as presented in the storyboard in Figure 5.3; (1) Each player puts their NFT player token in the chosen home and takes turns rolling the die. For a player to start moving their character around the tabletop, they need to roll a six. Once the player accomplishes this task, they may roll the die again and move their token clockwise according to that number. (2) As mentioned, a few fields have special symbols that indicate a challenge, including "+1", "-1", and "VS.". (3) If a player lands on "-1," they must remove one LEGO brick from their token (4) and put it on the jackpot plate, (5) while "+1" allows the player to take a brick from the plate and add it to their token. (6) In the case of "VS," the player must choose another player they want to fight. They may only select a player on the opposite side from where they are standing or a player positioned on a field with their start color. (7) The character composed of the most bricks wins the battle, and the other is sent back home - as in traditional Ludo. (8) Two players may also battle against each other if they land on the same field.

When completing one round across the entire board, the player may enter the finishing path, indicated by the fields with their start color. (9) The player who arrives at the center first after rolling the precise number of steps on the die, wins and receives all bricks located on the jackpot plate. Meanwhile, the other players may compete until reaching it themselves. When the game is over, each player keeps their NFT character in its current state and uses it for the next session.

5.3 Trivia Brawl

Trivia Brawl is a NFT-inspired version of the well-known board game *Trivial Pursuit* [47]. The game is played by two to six players or in teams, in which they compete to acquire all five subject cards and earn LEGO bricks by correctly answering questions. Like Ludo Brawl, Trivia Brawl applies diverse NFT characteristics to enhance traditional Trivial Pursuit games: 1) *upgradability*, 2) *trading*; 3) *transient*, and 4) *ownership*. Instead of achieving multiple wedges to fill their scoring token, as in Trivial Pursuit, the players seek to acquire all subject cards and win the number of Bricks placed on the jackpot plate to *upgrade* their NFT player token. *Upgradability* is also explored by allowing the players to take a LEGO brick from the remaining pool of bricks when having achieved two of the same subject card. Next, the players may gamble with their token and remove two wrong answers by *trading* a brick of their own.

Trivia Brawl and Ludo Brawl are both a part of the game collection named *Builder Brawl*. The reason for creating a board game collection consisting of two games was to investigate the *transient* and *ownership* characteristics of NFTs. Specifically, we wanted to demonstrate *transience* by the participants experiencing how the outcome of a game session may influence the next, regardless of game type and context. When using the same NFT player token across two games, we also hoped to invoke feelings and reflections on *ownership* towards the NFT. Furthermore, two games would allow us to examine different ways of incorporating NFT *upgradability* and explore the participants' preferences. As such, we deliberately designed Ludo Brawl as luck-based to acquire LEGO bricks, while Trivia Brawl focused on trivia knowledge and risk taking.

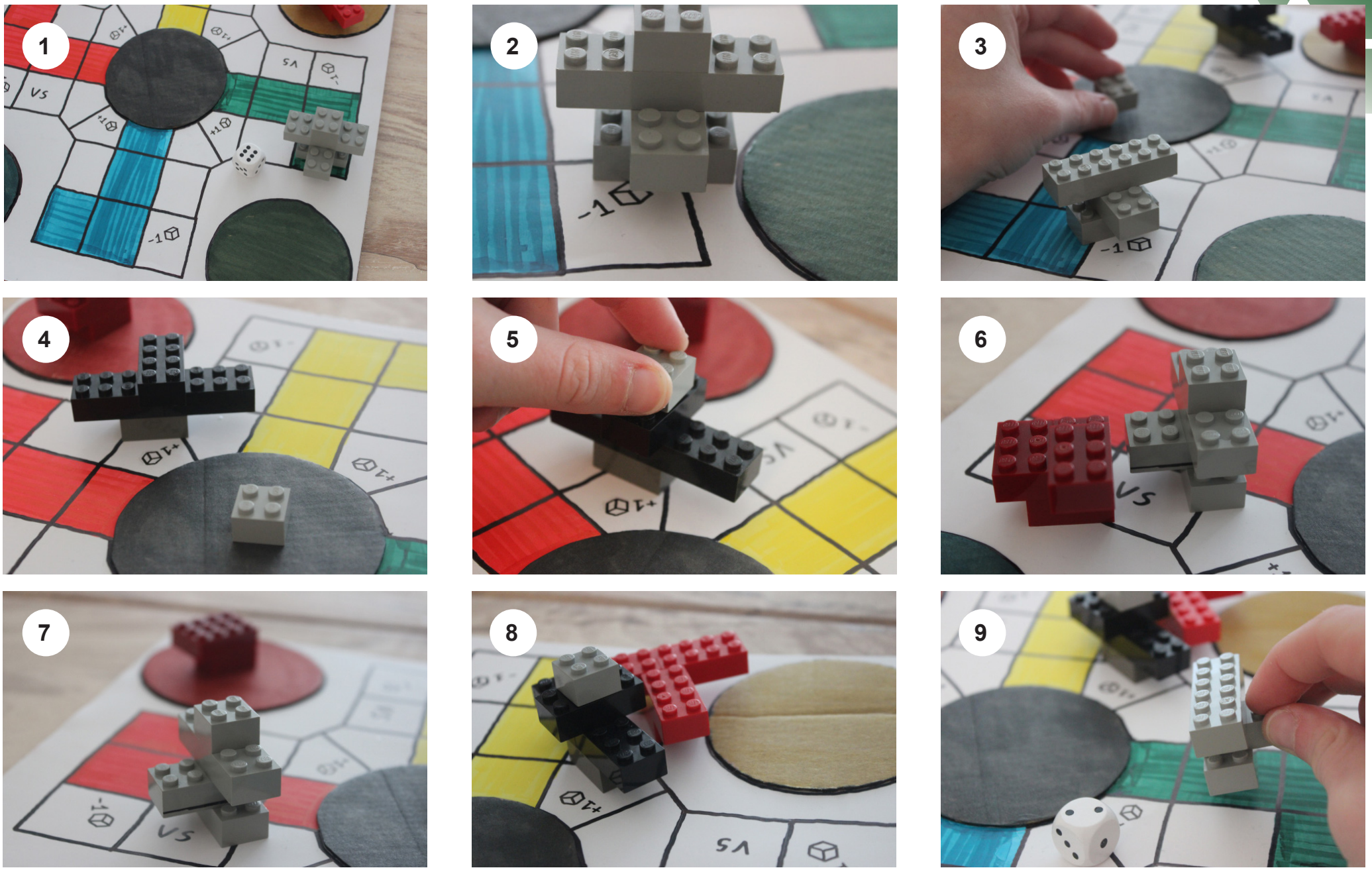


Figure 5.3: *A simple storyboard explaining the gameplay of Ludo Brawl.*

5.3.1 Components and Implementation

Trivia Brawl consists of five kinds of components (Figure 5.4); (1) a tabletop, (2) 100 questions-and-answers cards, (3) NFT player tokens, (4) additional LEGO bricks, and a die. As with Ludo Brawl, we created the tabletop using paper and colored markers to draw up the game area. The tabletop layout resembles the board of Trivial Pursuit but without the finishing path and only five-colored fields, including a (5) *jackpot plate* in the middle. The subject cards were made in Indesign and subsequently printed to ensure that the players could easily read them. We made five categories of cards, each represented by a specified color: green = “science and nature”, blue = “sports”, purple = “entertainment”, red = “art and literature” and orange = “geography”. The subject cards include one question and four answers, where only one option is correct. The players’ NFT tokens are pre-assembled after playing Ludo Brawl, but the players may change its shape and look as they prefer.

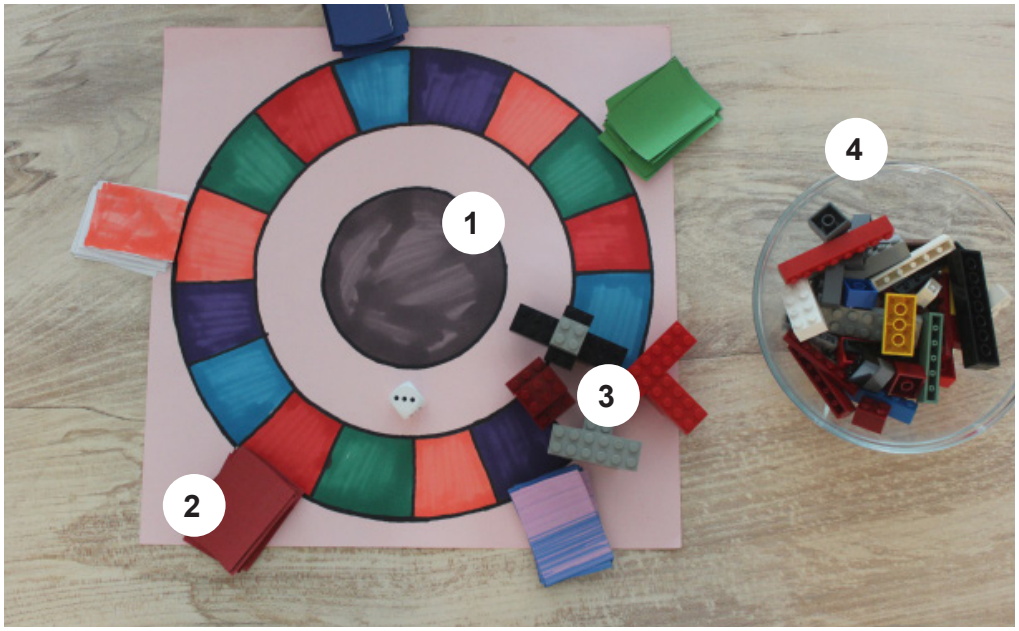


Figure 5.4: *An overview of the components in Trivia Brawl.*

5.3.2 Preparing to play

To properly set up Trivia Brawl (Figure 5.4), (3) each player puts their NFT player token on the white field and (2) places the questions-and-answers cards next to a corresponding color field. (3) The cards lay with their colored background facing upwards, ensuring that no player may perceive the answers or questions. (4) The remaining pool of bricks are stored in a bowl beside the tabletop, making them easily accessible for the players during the game.

5.3.3 Gameplay

To start the game (Figure 5.5), (1) A player rolls a die, (2) after which they move their NFT player token with the corresponding steps. (3) When landing on a colored field, another player picks up a subject card from the appropriate deck and reads it aloud. (4) The player may then select one option from the list of answers or (5) remove two wrong answers by giving up a brick of their own, (6) placing it on the jackpot plate. If the player answers correctly, they may keep the subject card, while a wrong answer provides nothing. (7) In the case of achieving an already acquired subject card, the player may pick a brick from the bowl of remaining bricks, which should not be confused with the jackpot plate, and (8) upgrade their player token. Furthermore, landing on the white field, the player is to choose which card they would like to get a chance of winning. The winner of Trivia Brawl is whoever obtains one of each subject card first. (9) This player is awarded the bricks on the jackpot plate and may upgrade their character accordingly.

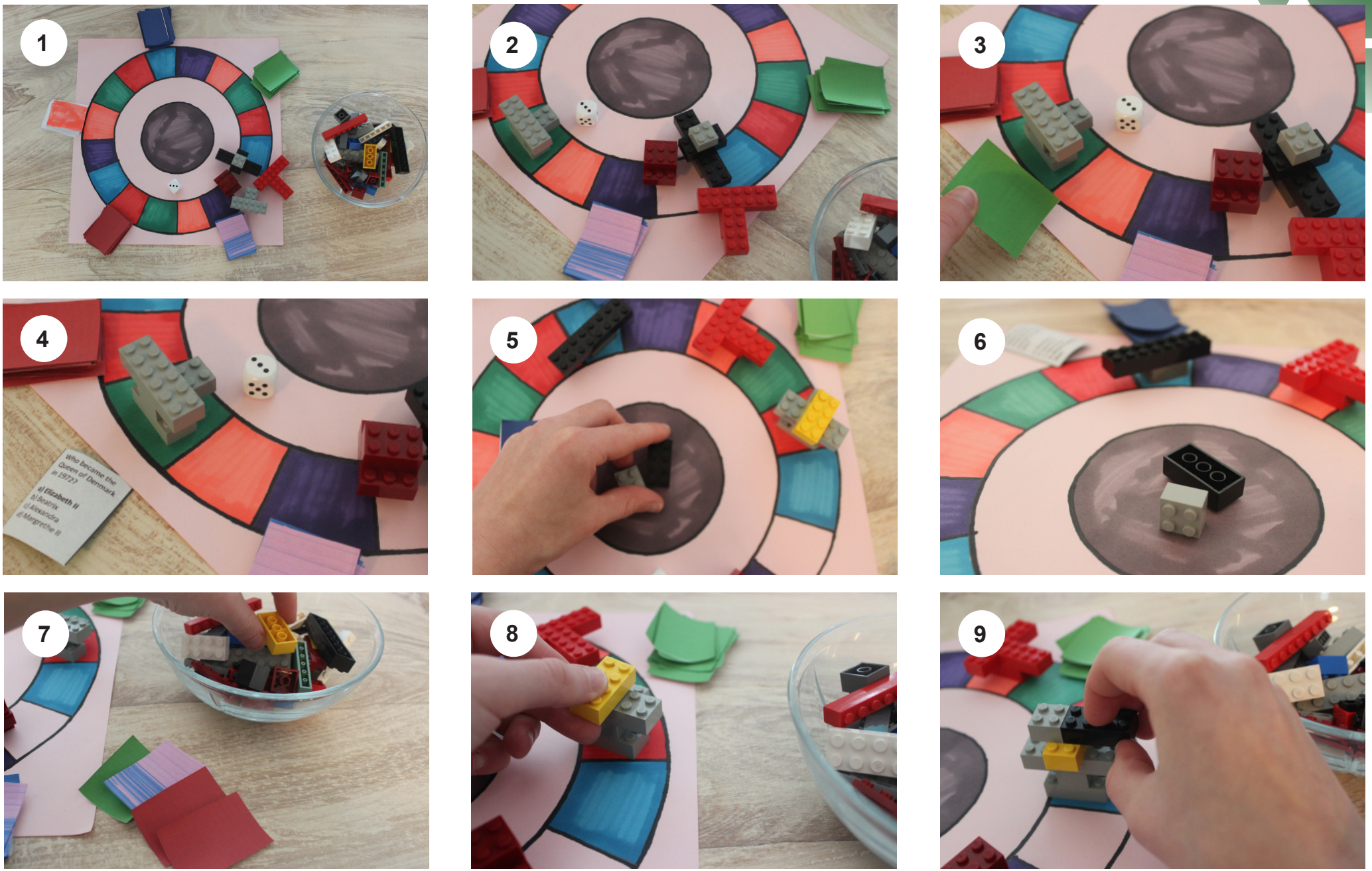


Figure 5.5: *A simple storyboard explaining the gameplay of Trivia Brawl.*

5.4 NFT against Reality

NFT against Reality is based on the popular board game *Cards against Humanity* (CAD), where players compete to create the funniest combination of words and sentences using one white and one black card [10]. In our game version, every white card represents an NFT. Specifically, the players own their deck of white cards and do not receive them during time of play like in the original game. Subsequently, the players store their cards in a personal *crypto wallet* instead of in the gamebox containing the black cards. Based on this, NFT against Reality differentiates from the original CAD with regard to storing game components and allowing players to own and trade NFT cards using crypto, implementing the characteristics of: 1) *ownership*, 2) *trading*, and 3) *Community-driven interactions*.

5.2.1 Components and Implementation

NFTs Against Reality consists of four components (Figure 5.6), (1) which is that of a deck of white and (2) black cards, (3) crypto wallets, and (4) paper currencies of 100, 200, and 500 Danish kroner. As one group member owned the original game, we utilized the white and black cards from this package rather than creating our own. Furthemore, we designed the crypto wallets in Indesign using different NFT-inspired themes to make the wallets more appealing and engaging to the participants. Thereafter, they were printed, folded, and taped as envelopes. We also made the paper currencies out of paper and used colored markers to differentiate between their monetary values; blue = 100 dkk, pink = 200 dkk, and green = 500 dkk.

Figure 5.6: *The components comprising NFT against Reality.*

5.2.2 Preparing to Play

Before gameplay, each player needs to have a crypto wallet ready, containing their white NFT cards and crypto coins (Figure 5.7). In the case of our workshop, each player got a wallet of 1500 paper currencies distributed in seven nodes and 15 random white-colored cards. Among these cards, the players select five to compete with during the game and put the remaining cards aside. Meanwhile, the deck of black cards is placed in the middle, with the CAD logo turning upwards, to make them easily accessible for all players.

Figure 5.7: The setup of NFT against Reality.

5.3.2 Gameplay

To begin the game (Figure 5.8), (1) a random player picks a black card and puts it beside the deck with the sentence present for every player to read. The player who drew this card is assigned the gamemaster of that round, but this role changes every round. (2) The remaining players then select one of their white-colored cards to pair with the black and put it face down on the table. When all players have chosen a white card, the gamemaster shuffles them to avoid seeing who placed which card on the table. (3) Hereafter, the gamemaster turns the white cards and reads them aloud in connection with the black (4) before selecting the card that creates the funniest combination. (5) The player who owns this card wins the round and may receive the black card, which indicates one point. All white cards used this round may not be used before the next game session. This procedure continues until the players have no white-colored cards left, and the winner is whoever has the most points. (6) After gameplay, the players are allowed to buy, trade or sell their current white cards with other players, or the facilitators which have the role of other traders.

Throughout this chapter, we have explored how to integrate all five NFT characteristics presented in our requirements by performing several design iterations and implementing three technology probes. Table 5.1 summarizes what principles we have included in each probe and which we seek to further investigate with participants to understand how they may apply as interaction design material. A cell with an "X" signifies that the technology probe encompasses the NFT characteristics, while an empty cell indicates otherwise.

Technology Probe	NFT Characteristics				
	Ownership	Transience	Upgradability	Trading	Community driven interactions
Ludo Brawl	X	X	X		
Trivia Brawl	X	X	X	X	
NFT against Reality	X	X		X	X

Table 5.1: *Overview of principles included in each technology probe.*

Figure 5.8: *A simple storyboard explaining the gameplay of NFT against Reality.*

6. NFT Board Game Workshop: An Exploration and Evaluation with Technological Probes

We arranged a *participatory workshop* to investigate the implementation of NFT characteristics as design material in Ludo Brawl, Trivia Brawl, and NFT against Reality. As defined by Jisc [22], a participatory workshop is an organized event wherein participants "*seek their opinions, extract knowledge, and solve problems in a collaborative and creative environment.*" The advantages of hosting this type of workshop are the active participant involvement, the short-term intensive learning, and effective generation of new design ideas [8]. With this type of method, we aimed to investigate the technology probes in a more natural and social setting, which is the very purpose of such probes [21]. In addition, the social situation is an essential part of experiencing and assessing board games, as they involve embodied interactions that come naturally to people. In this chapter, we present the recruited participants and selection process, followed by a description of the workshop setup and procedure. Hereafter, we explain the method for analyzing data, including the workshop findings.

6.1 Participants and Recruitment Process

We recruited six individuals for the participatory workshop, where each resided within the expert group of either *interaction designers* (Table 6.1) or *NFT enthusiasts* (Table 6.2). As specified in the research questions, our study builds on two expert domains: 1) non-fungible tokens and blockchain technology, and 2) Interaction Design. Based on this, we chose to define two expert groups for recruiting workshop participants, each with distinct criteria. The criteria for the interaction designers was to have expertise within the field of human-computer interaction (HCI). Meanwhile, the NFT enthusiasts were required to have a decent understanding of NFTs and blockchain technology, such as investing, trading, or having a general interest in the subject. A shared criterion for both expert groups was that they had to be friends or familiars to encourage social processes; as if they were playing board games in any other evening. In respect of the participant's privacy, their names are kept anonymous throughout the report. From now on, we refer to them as either "IxD.X" or "NFT.X", where the "X" signifies a number that differentiates the three participants of each group. To exemplify, "IxD1" specifies the first participant of the interaction designers, while "NFT2" implies the second participant of the NFT enthusiasts.

Name Llabel	Age	Interaction Design Semester
IxD1	27	10th
IxD2	27	10th
IxD3	27	10th

Table 6.1: *An overview of the participants recruited for the group of Interaction Designers.*

Name label	Age	Knowledge surrounding NFTs (1-7)
NFT1	23	4
NFT2	25	7
NFT3	27	5
**Answer based on a questionnaire (Appendix B) regarding the participants' knowledge of NFTs, where "1" is no experience, and "7" is a lot.*		

Table 6.1: *An overview of the participants recruited for the group of Interaction Designers.*

We recruited participants by searching our personal networks; applying the criteria of each expert group to determine whether people qualified as participants. As we reside within the group of interaction designers ourselves, it was convenient to recruit other interaction designers or students enrolled in an IT education. As several IXD students who fulfilled the criteria volunteered, we regarded their level of expertise and excluded those with a degree below the 7th semester. However, as NFTs are a new and emergent technology, very few knew about the technology and could classify as NFT enthusiasts. We selected only one NFT enthusiast after the initial search, but conveniently, this participant had connections within the crypto community and could point us in the direction of two additional NFT enthusiasts.

6.2 Conducting the Workshop

To target and extract the domain expertise of each participant group, we conducted two separate workshop sessions. By having the interaction designers in an individual session, we also attempted to utilize their skills in producing design ideas. Each session consisted of two observations, two focus group interviews, and a creative task, which we framed according to the expert groups. We combined these methods to understand the interactions and opinions about the technology probes while also allowing them to explore and reflect upon design possibilities.

6.2.1 Preparations

To assure that no essential parts of the workshop were left unplanned, we applied the book on participatory workshops written by Champers [12]. This book introduces 21 questions to help practitioners prepare, navigate, and facilitate a participatory workshop to prevent unforeseen issues and ensure maximum data-gathering efforts (12). Taking inspiration from this list of questions, we established a list of workshop preparations (Appendix A) and a guide to direct the facilitator during workshop activities (Appendix B). The guide outlined the workshop procedure, an introduction to the participants, interview questions, and gameplay descriptions. Besides this, we also drafted a consent form (Appendix C) that informed the participants of their rights and influence on the Master Thesis project.

6.2.2 Setup and Procedure

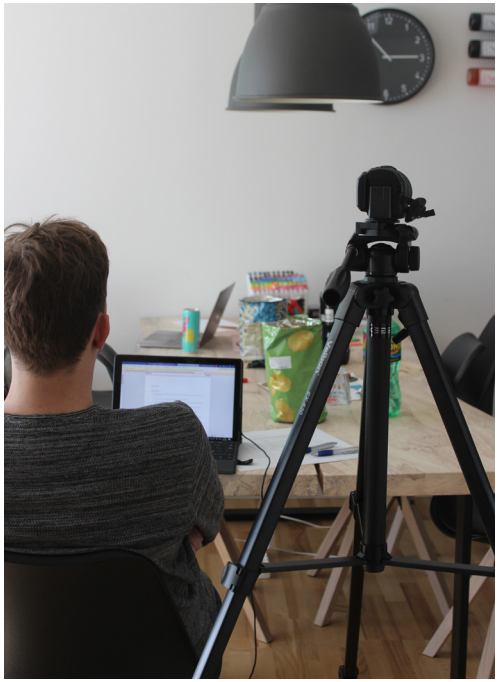
Attempting to recreate the setting and atmosphere of a traditional board game session, we held the workshops in the living room of one group member. The participants were seated around a dinner table with the technological probes and beverages placed in the middle. In addition, the physical setup consisted of a video camera and an audio recorder,

documenting all interactions and comments made by the participants. This setup, viewed in Figures 6.1-6.2, allowed us to extract the crucial parts of each session during the subsequent data analysis. Before the workshop, we also assigned each group member a specific role to enhance facilitation. These roles included: 1) a *facilitator*, who had the responsibility of guiding the sessions and actively listening to the participants; 2) a *co-facilitator*, who had the task of taking notes and probing questions based on interesting observations they came across; and 3) a *technician*, who was responsible of the recordings and other practical technicalities.

We divided the workshop into three parts; the two first parts consisted of one observation and focus group each, whereas the third involved a creative task. In the first part, the participants were asked to play *Ludo Brawl,* followed by *Trivia Brawl* to demonstrate the NFT characteristic of *transient* and *ownership*, while the co-facilitator and technician observed and noted any points of interest. Hereafter, we held a focus group interview with open-ended questions to avoid concise answers of yes and no. The focus group was also semi-structured, allowing the facilitator and co-facilitator to probe into interesting observations or unclear statements. Although most questions were similar for the two expert groups, asking them about *transience* features and feelings of *ownership* towards their NFT LEGO game token, we framed a few questions to target the specific knowledge of the interaction designers as with the NFT enthusiasts.

In the second activity, we applied the same procedure and began by observing the participants playing *NFT against Reality*. During this game, the facilitator and co-facilitator acted as a physical marketplace, providing the participants with the opportunity to trade, sell, and buy additional NFT-cards. As such, the technician had the responsibility of taking notes of significant actions or expressions made. The participants were also allowed to trade cards with each other or arrange a bidding war. In the subsequent focus group interview, we concentrated on trading within board games, but asked about their experiences of *ownership* and *community-driven* sociability.

In the third part, we challenged the participants on their creativity and tasked them with exploring future design possibilities (Appendix B). As the interaction designers are visually strong, we utilized their strength and asked them to sketch ideas of: 1) How to change the probes, and 2) how to use NFTs as interaction design material in other contexts. The NFT enthusiasts, who were more technical, received the task of ideating ideas for implementing NFTs in new contexts and existing products.



Figures 6.1 & 6.2: *The physical setup of the workshop.*

Category	Subcategory	Interaction Design Reference	NFT Enthusiast References	Total
General	NFT Technology	7	7	14
	Ownership	3	6	9
	Play-to-earn	0	2	2
	Rewards	1	10	11
	Social Interaction	3	2	5
	Transient	7	3	10
	Trading	5	14	19
	Upgradeble	5	10	15
Hybrid Board Games	Experiences	4	2	6
	Ideas	8	2	10
Builder Brawl - Ludo Brawl	Constructive Criticism	6	8	14
	Positive Feedback	6	5	11
Builder Brawl - Trivia Brawl	Constructive Criticism	10	6	16
	Positive Feedback	4	3	7
NFT Against Reality	Constructive Criticism	7	14	21
	Positive Feedback	3	1	4

Table 6.3: *The count of references found from coding the transcription of the first workshop.*

6.4 Workshop Findings

In the following section, we elaborate on the findings presented in Table 6.3 and exemplify them with quotes from the workshop participants. Instead of presenting the results from each workshop session as individual sections, we combine the observations and comments from both expert groups. The individual participants are referenced according to Table 6.1 and Table 6.2.

6.4.1 Transience

Comments from the participants suggested that they enjoyed the transient features integrated into the three technology probes while using this characteristic as design material would depend on the context. Several participants related transience to the aspect of ownership, as they evolved a certain relationship and commitment to their NFT player token after using it in two games. For example, as IxD3 explained about Builder Brawl: *"I found it quite interesting to have a character you can bring to different games but also in different contexts, like with different types of people. Then I believe it will become a lot more personal, like it is the one I send out in battle."* IxD2 also appreciated the transience in Builder Brawl and compared it to another digital game that would benefit from this characteristic: *"I kind of like it [the transient aspect] in a way, but it really depends on what composition it is used in. In Ludo Brawl, where you can build bricks but also lose bricks, it is okay. If you take a game like Runescape, I cannot stand that you spend so much time trying to achieve cool features, and then lose everything when dying".*

Despite appreciating the feature of using their LEGO player token across game sessions and platforms, the participants found the transient functionality to also bring a sense of unfairness to Ludo- and Trivia Brawl. Two out of three interaction designers addressed that the transient dynam-

ic contributed to a certain unfairness as players may have significantly distinct starting points. For instance, IxD3 commented that *"[...] now [in Ludo Brawl], we began with the same outset, as we all had three bricks. However, if the idea [of transient] is to go separate ways and then play a new round later, a player may start with 15 bricks, and I may still only have three bricks."* The same participant explained further that the type of board game influences the degree of unfairness; in Ludo Brawl, she would not care about having one brick because the game is about luck, while Trivia Brawl focused on knowledge. NFT3 expressed a similar concern, commenting: *"[...] when it is all about luck, it feels a bit indifferent, as you are not in control of whether you win or lose more bricks"*, with NFT2 agreeing.

Continuing the discussion, the participants mentioned how the transient unfairness also impacts whether a player wishes to gamble their bricks. IxD2 elaborated that *"[...] for example, if you had two bricks and I had 15, then I would not have any issues giving up a few bricks to increase my chances. You would, however, not be able to do it."* Based on this issue, IxD2 suggested that players with considerably fewer bricks could receive an advantage in the beginning of Trivia Brawl. However, the participant later admitted that it would be like cheating, as the other players would lose their benefits of playing well in previous games. NFT3 proposed that Ludo Brawl could enable players to acquire more LEGO bricks, such as increasing from "+1" to "+3", commenting: *"It might be cooler if in the first game you got more opportunity to go for more bricks, so you could be better in the next game [...]"*. Another solution mentioned by both expert groups involved creating game levels based on the number of LEGO bricks in each player token, where fewer bricks would indicate easier Trivia questions.

6.4.2 Uniqueness through Upgradability

A recurring theme in both focus groups was the lack of uniqueness reflected in the board games and their associated game pieces. As a few participants emphasized, an essential part of owning NFTs is their rarity and scarcity. To exemplify, NFT2 and IxD2 both commented on how players should be able to customize and upgrade their card deck in NFTs against reality, as the white cards seemed abundant and indifferent. To ensure that no cards would be alike, NFT2 also proposed that *"through validation of the network, players can investigate whether a card exists or not; it is easier to validate than pictures, videos, etc."*. Regarding upgradability, two of the interaction designers also commented that they liked the ability to choose their brick in Trivia Brawl after obtaining two cards of the same color. IxD3 explained having an idea of the aesthetics of the LEGO character and caring about its colors, as this would create uniqueness. Furthermore, 4 out of 6 participants mentioned, in various ways, how the Lego bricks in Builder Brawl should be specialized and limited. For example, NFT3 talked about having "season bricks," and NFT2 explained that *"[...] maybe you participated in a specific event and received a brick hereafter."*

The NFT enthusiasts also suggested enhancing the uniqueness of the technology probes by making in-game assets more limited and difficult to achieve. However, the interaction designers believed that reducing upgradability would remove the creativity, engagement, and feelings of attachment otherwise provided by the NFT characteristic. To elaborate, two of the NFT enthusiasts expressed that the bricks in Builder Brawl should be harder to retrieve, as players can easily upgrade and downgrade their NFT character. NFT2 mentioned that he did not prefer Ludo Brawl because of the varying uncertainty of losing bricks, while he felt that Trivia Brawl lacked risk. He subsequently suggested that Trivia

Brawl could provide the players with *"[...] three lives, and if you answered incorrectly three times, you would need to leave the game for a certain amount of time. Then you could buy extra lives or give up bricks to receive power ups, such as a hat that contains two extra lives."* NFT2 and NFT3 also proposed that Builder Brawl should have game rounds with specified goals, such as competing to win *"rare, epic, or legendary bricks''*, as NFT2 commented, or *"unique features, such as gloves to one's character"*, which NFT3 added. Contrarily, all interaction designers mentioned how the upgradability promotes creativity and commitment in the game, enhancing the overall user experience. For example, IxD1 explained about Builder Brawl that *"it encourages creativity, and even though it is a Lego 'thing', you become attached to your character and wish to develop it,"* and IxD3 commented *"[...] you became committed when you could lose a brick, it almost hurt because you had an idea of how the character should look. But it was fun; you wanted to build different things with it [the character]."* Based on this, IxD3 also mentioned how the upgrading and downgrading provides "*a thrill*", as one may risk losing everything. Moreover, IxD2 related upgradability to the well-known concept of Build-a-bear and mentioned that *"whatever it may be, it is very nice to personalize things and add different features [to your character]."*

6.4.3 Trading and Play-to-earn

While several participants found trading as a beneficial design material when considering other commercial board games, such as Monopoly and Matador, they were not as convinced by our three technology probes. As NFT3 explained, there are various ways of implementing trading in board games, but these relate to the overall purpose and motivations for playing. The participant then provided two distinct examples of trading using the commercial games Monopoly and Catan: *"It [trading] depends on how it is integrated into the game. In Monopoly, you invest your money into better acquisitions in the hopes of people landing on them, making them pay you money. This is opposite to Catan, where you are always going for something specific [cards] and can then trade towards that goal, which I think works better"*. The remaining NFT enthusiasts agreed with this statement before NFT3 added *"[...] Catan is more strategic when it comes to trading."* However, after bringing up the subject of play-to-earn, the characteristic of trading became more apparent to the NFT enthusiasts. For example, NFT2 and NFT3 found NFT against Reality to have a meaningful implementation of trading when considering play-to-earn mechanics, with NFT3 saying *"I like it [play-to-earn] when considering this [pointing at NFTs against reality], then there is a reason to play or buy cards, since you can use it [rewards] within the game"*. Meanwhile, NFT1 addressed one of the main concerns regarding play-to-earn mechanics, commenting that *"It is not fun if those who have the most money also have the best cards"*. The interaction designers, on the other hand, had no associations with the concept of play-to-earn.

6.4.4 Social Interaction

Concerning social play, observations and comments proposed that the participants experienced all three technology probes to encourage social interactions but in distinct ways. Our findings suggest that the board game type and the social situation in which the play occurs affect sociability. To exemplify, when asked about social interactions in NFT against Reality, NFT2 expressed that *"It can be related to the game type. It brings out wild and dark humor"*. The participant continued explaining that "You can laugh about it before, during and after the game, which also creates a bit of conversation topics, such as; *"That was a really good card you*

put there!". These statements confirmed our observations, as we noticed the participants continuously laughing about the combinations of words and pointing out the funniest ones. In regards to Builder Brawl, IxD1 explained that Ludo- and Trivia Brawl provided different levels of social interactions due to their gameplay: *" [...] you were more against each other in the first game [Ludo Brawl] because there you could duel. It was maybe a little more passive in Trivia Brawl"*. NFT2 was more concerned with the social setting and composition of people than the game type itself, explaining how these factors contribute to specific social interactions: *"I do not know if it is just because we are friends and know each other that you want to help and such. If it was other people and there was something else on stake then I probably would not say anything"*. Trying to rationalize these thoughts, the participant added: *"I think it is because we know each other, because if I was sitting with some random person I did not know and just wanted to win then I would have just said ´hmmm hmm´ wrong"*.

6.4.5 Ownership

As the abovementioned findings suggest, feelings of ownership and attachment towards an asset derive from implementing the four remaining NFT characteristics; transience, upgradability, trading, and community-driven interactions. The participants explained that the transient features promoted commitment to their LEGO player token and NFT cards, describing it as sending "a personal character into battle" during each time of play. After a period of time using their assets in board game play, the participants believed they would develop a certain relationship. Through the use of upgradability, the participants became more attached to their LEGO player token as they explored different shapes and customized aesthetical looks. For example, as NFT3 expressed: *"You get a sense of ownership for the figures you make, which also makes you less keen to sell them, as you want to build something out of them"*, referring to Builder Brawl. In regards to trading, several participants suggested that trading NFT cards to develop a specific card deck would, in turn, provide a sense of attachment. The interaction designers also valued the ability to own the white cards in NFT against Reality, as IxD2 explained: "*The assurance that it is my property is very nice, instead of being randomly given bad cards,"* comparing the board game with traditional Cards against Humanity [10].

6.4.6 Physical NFTs

All six participants seemed to like the idea of experimenting with physical NFTs, such as in board games, as it brings more sentimental value towards the assets. For example, NFT1 explained that *"if you own the digital version of an NFT, then you have the rights to order the physical version."* The participant emphasized that physical NFTs may provide owners with an enhanced feeling of ownership towards the NFT. He continued explaining that NFTs are more secure as tangible items, as they cannot vanish if the market shuts down or technology fails. However, NFT2 addressed the issue of creating and ordering several physical duplicates, which decreases the rarity and uniqueness of the NFT. Further, NFT2 added that *"when physical parts are involved, it is harder to navigate them."* As a solution to these issues, NFT1 suggested creating rules or constraints.

6.4.7 Hybridity

Despite only a few participants having played a hybrid board game before, they believed that the concept of combining digital and physical el-

ements could bring forth new possibilities. Among the three participants who had experiences with HBGs, the digital component was always a mobile application, while the physical part included cards or game boards. For example, NFT2 mentioned a board game called Munchin, where players may apply their personal devices for assistance during play. Specifically, the mobile application acted as a gamemaster, keeping track of the players' scores and resources. IxD1 introduced the hybrid version One Night Ultimate Werewolf, as introduced in *our board game analysis (Chapter 3), and his experiences of playing: "I have not tried anything other than one night werewolf, but I thought it's co*ol that it's such a thing. There are many possibilities that open up with it".

6.4.8 Builder Brawl - Constructive Criticism

When the two groups were asked about first impressions regarding Ludo Brawl within the Builder Brawl category, IxD2 started with: *"I actually think it was interesting and fun that you could lose bricks and also challenge each other. The only negative thing I could say is that it was over quickly. Normally in Ludo you have 4 [referencing to player tokens] to play with and therefore have more options"*. The discussion quickly turned towards the special fields on the board game where IxD2 and IxD3 thought it could be interesting to add more special fields, where IxD1 responded: *"I actually liked there were so few [special fields]. When there is only plus, minus and versus makes it accessible and the focus lands on building one's character, which I thought was nice"*. The NFT enthusiasts commented on the versus fields, with NFT2 stating: *"We did not get to duel each other that often", where NFT1 responds: "Are we not supposed to be 4 players? [points at the board game]"*, and NFT2 reacted: *"Yeah if we were 4 players, then it would probably have happened more often"*, thereafter the group discussed extending the game time would probably also have benefitted the overall game experience. The NFT enthusiasts then discussed how long they took to actually get into goal, since they were all three in their corresponding "winning lane" for a number of minutes, where NFT3 suggested: *"It could be interesting if there were a special field here [pointing at winning lane] which had an impact on the game, since we all three just randomly threw the dice in the last couple of minutes and nothing happened"*. NFT1 suggested a change in the + and - fields: *"I think if you [the player] had the option to further build upon the character by changing the +1 to +2, the feeling of progression would be better"*, which led to NFT3 wanting to alter the versus field: *"I think it would be more fun to change the way the versus field works by maybe having a challenge of throwing a dice and whichever is gets the highest number wins, and then gets a brick from the other person".*

When asked about Trivia Brawl, the Interaction Design group all agreed that it took too long, with IxD3 commenting: *"I think it took a bit too long, but that is maybe because the game type is not my personal preference"*. When the groups were asked about the gambling aspect of the game, i.e selling your bricks to reduce number of answers from 4 to 2, both groups agreed that the incentive to do so was not very appealing, but the game mechanic was interesting, where player IxD1 from the Interaction Design group commented: *"I didn't feel like risking it, mostly because i didn't know if it was worth winning the game as a whole."*, and IxD2 added: *"I maybe also think it is mostly obvious later in the game where you know you only need one or two cards to win, then the incentive to gamble is higher"*. The NFT enthusiasts had the same thoughts, with NFT2 commenting: *"I liked the whole concept of having to sell your bricks for an advantage. We unfortunately didn't get that many bricks in the previous game, so we were not as compelled to do so. If we had more bricks then we would probably have used it, then the jackpot pool*

also makes more sense", which led to NFT1 suggesting: *"It could also be interesting if there were a special field where you can win 2 color cards instead of 1, then the incentive to selling a brick would be higher"*. An overall discussion of balancing the chance of winning from both groups arose, with IxD3 suggesting: *"If the player has a lot of bricks coming into the game, then the difficulty of the questions could be higher for that individual"*, which the other two players quickly agreed upon. NFT2 also suggested a life system when considering the game in a digital context: *"There is not really any risk of playing the game [pointing at Trivia Brawl], but to ensure that people don't just keep playing it to earn bricks, a life system could be implemented, where one loses a life each time a player answers incorrectly and gets kicked out from the game"*.

6.4.9 NFTs against reality - Constructive Criticism

When the two groups were asked of their initial thoughts regarding NFTs against reality, IxD3 started with: *"I think it was hilarious, mostly because Cards Against Humanity is fun, but i also liked the fact you could put together your own cards, especially since everyone have different thoughts of what is fun"*, meanwhile NFT3 stated: *"I don't see a point of playing the game in its current state, as there is no reward for winning, which means there are little to no motivation to play"*. When the groups were asked about the trading aspect, IxD3 said: *"[...] I don't know how specifically it should work, but maybe instead of the trading round, there were just six white cards on the table, and the player with least points was allowed to be the first to buy one… To ensure the person who is behind gets a little head start"*. NFT2 made a quick remark: *"I would probably keep the buying round before the game, not in between rounds"*, where NFT1 responded: *"Or make it more random in the trading round, so there is a risk of you getting a good or bad card, like in card packs, you don't know what is inside"*, which quickly led to a discussion of how players should be able to gain cards, with NFT3 suggesting: *"You could also do it like they do in Magic The Gathering, where there is different seasons and players can only play the cards that are available in the current season, which also ensures that players with a lot of money don't always have all the best cards".* Both groups quickly agreed upon that being able to see other players' cards during the trading phase could make people biased when selecting a winner for each round, and they both wanted a system that keeps one's cards secret in between rounds, as well as wanting a reward for winning a game, such as a new card to ones collection, or even cards with special uses, e.g. linking multiple cards together.

6.5 Summary

Through our findings, it was apparent that the two participants groups had different viewpoints on NFT technology and hybrid board games. While both groups touched upon many of the same subjects, the NFT enthusiasts group was quick to delve deeper into discussions regarding NFTs, crypto and blockchain technology, while the Interaction Design group focused on the subject of hybrid board games. However, as the workshop progressed, the interaction designer became more interested in learning about NFTs, as they saw potential in utilizing this technology through the perspective of our technology probes. With the knowledge gained from these findings, we will revisit the first version of requirements and reassess them.

7. Designing the Hybrid Board Game

In Chapter 7 we apply findings from the participatory workshops to specify the direction to pursue in establishing our hybrid board game prototype. We use the observations and learnings from the focus group interviews to refine our existing requirements and establish a final requirement list. This selection of requirements, together with the design ideas of the workshop participants, are then adapted to sketch new HBG concepts that implement NFT characteristics. Lastly, we present the final design concept for our HBG prototype.

7.1 The Final Selection of Requirements

As mentioned in Chapter 4, our initial selection of requirements contained 23 requirements, including eight functional, seven non-functional, and eight NFT-related. We kept these requirements broad to avoid constraining our creative process in the first design phase. However, after analyzing the data from the workshops, it became more apparent what our HBG prototype should do and perform according to the perspective of the player. Based on these new insights, we felt it necessary to review the current requirement formulations and select those still applying for the HBG prototype. We also included a pair of new requirements based on additional needs from the workshop participants, which we had not considered ourselves. In the following section, we present the final list of 22 requirements, which encompass 17 existing requirements and five new requirements. We briefly explain why these were selected and why the remaining five requirements were disregarded.

7.1.1 Selecting Requirements

By conducting a second iteration of eliciting requirements, we could review which requirements would pertain to the high-fidelity prototype, which would not, and which would need an update. We revised the established requirements list, introduced in Chapter 4, by considering our workshop findings and relating each requirement to the expressions of the participants. Being interaction designers ourselves, we also included those we believed were essential for constructing an HBG prototype. Through this, we selected 17 requirements, including six functional, six non-functional, and five NFT related.

The six functional requirements we selected from our existing requirement list included F.1-F.4 and F.6-F.8. (F.1-F.3) We decided to keep the requirements F.1 and F.2 as feedback is essential when a board game implements digital components, while F.3 provides audial-visual aesthetics to present feedback and game features. (F.4) Requirement F.4 was selected as the opportunity to play without the digital part would be helpful if the prototype fails during evaluation. (F.6-F.8) We chose requirements F.6-F.8 because utilizing computing power to keep track of less engaging chores or tasks could prove valuable to players.

The six non-functional requirements we chose to include in the final list were NF.1-NF.6. (NF.1-NF.2) We kept requirements NF.1 and NF.2 as they relate closely to the fundamental aspects of HBGs, which is that of combining the physical and digital. (NF.3 and NF.6) We selected requirements NF.3 and NF.6 because the game area and people surrounding the pro-

totype should be accessible to all players. (NF.4) We decided to keep requirement NF.4 to support the material richness and tangible play of analog board games. The four NFT-related requirements selected for the final selection included NFT.1-NFT.5. (NFT.1-NFT.2) We chose requirements NFT.1 and NFT.2 because they would enable us to investigate transience properly, giving options for dynamic alterations and utilization of NFTs. (NFT.3) We selected NFT.3 as the workshop participants liked the characteristic of ownership and feeling of attachment. (NFT.4) Requirement NFT.4 was kept to ensure that no negative characteristics of play-to-earn is brought into the prototype. (NFT.5) The last requirement that was decided to keep was NFT.5, as NFTs are often related to that of communities.

7.1.2 Including New Requirements

The workshop findings uncovered new needs and aspirations that we had not regarded when eliciting the first list of requirements. These considerations provided five additional requirements, viewed in Table 7.1, which we classified according to our pre-established categories of functional, non-functional, and NFT-related. This resulted in three new functional, one non-functional, and one NFT-related requirement. Similar to our existing requirements, we prioritized the new ones according to MoSCoW.

(F.9) The ninth functional requirement concerns that the HBG prototype should incorporate interactive player-versus-player interactions as a part of the gameplay, such as mini-games where all players compete. We included this requirement as several participants expressed that more engaging interactions between players encourage playfulness and sociability. (NF.8) The requirement states that the HBG prototype should encourage risk taking by providing rewards. Several participants felt that the reward of winning a game was too low for them to consider taking risks during playtime. (F.10) The third requirement outlines that the board game of the HBG could be customizable and modular to enhance feelings of ownership. This requirement emerged from a broad discussion about the customizability and upgradability of NFTs, wherein the participants found the feature beneficial. (F.11) The fourth requirement implies that the HBG prototype could implement diverse difficulty levels to create a balance between players. We created this requirement as multiple participants stated that players should have similar starting points or resources to avoid unfair advantages. (NFT.8) The fifth and last requirement describes that the HBG prototype could present NFTs in both physical and digital versions.

ID	Requirement Category	Short Description	Prioritization
F.9	Functional requirement	Implement interactive player-versus-player challenges	Should have
NF.8	Non-functional requirement	Ensure motivations for taking risks	Should have
F.10	Functional requirement	Enable players to customize the board game	Could have
F.11	Functional requirement	Include dynamic levels of difficulty to open a broader range of accessibility	Could have
NFT.8	NFT-related requirement	Presenting NFTs in both a physical and digital form	Could have

Table 7.1: *An overview of the new requirements added after the participatory workshop.*

ID	Functional Requirement	Prioritization
F.1	Support interaction between player and hybrid board game	Must have
F.2	Provide meaningful feedback to the players about the state of the game	Must have
F.3	Utilize digital aesthetics to enrich the gameplay	Must have
F.4	Allow players to continue playing if technology fails	Should have
F.6	Automation cognitive-demanding tasks	Should have
F.7	Automatic and continuous tracking of user progression	Should have
F.8	Automatic and continuous tracking of game state	Should have
F.9	Implement interactive player-versus-player challenges	Should have
F.10	Enable players to customize the board game	Should have
F.11	Include dynamic levels of difficulty to open a broader range of accessibility	Could have

Table 7.2: *The final selection of functional requirements.*

7.1.3 Excluding Excessive Requirements

We decided to deselect five requirements from our preliminary requirement list (Table 7.2), including one functional, one non-functional, and three. (F.5) We disregard requirement F.5 because the objective of our HBG prototype is to investigate the implementation of NFT characteristics as interaction design material. Managing the HBG setup is a commercial issue and not an aspect we seek to examine during the evaluation. (NF.7) We removed requirement NF.7 for a similar reason; enabling the participants to transport the HBG prototype to a social event is a commercial issue and not critical to the project objective. (NFT.5-NFT.7) Finally, we deselected NFT-related requirements NFT.5 to NFT.7 as multiple workshop participants expressed that trading aspects during play were more of an obstacle than a playful experience.

ID	Non-Functional Requirements	Prioritization
NF.1	Provide meaningful digital implementation to ensure tangibility	Must have
NF.2	Utilize tangible interaction to enrich game experiences	Must have
NF.3	Enable face-to-face and gestural social interaction	Must have
NF.4	Provide an enjoyable level of automation	Should have
NF.5	Hide confusing and non-essential electronic components	Should have
NF.6	Game area visibility	Should have

Table 7.3: *The final selection of functional requirements.*

ID	NFT-related Requirements	Prioritization
NFT.1	Implement transient features	Must have
NFT.2	Enable upgradability of NFT game components	Must have
NFT.3	Evoke sense of ownership towards assets	Must have
NFT.4	Avoid negative play-to-earn mechanics	Should have
NFT.5	Shareability in community	Should have
NFT.9	Presenting NFTs in both a physical and digital form	Could have

Table 7.4: *The final selection of NFT-related requirements.*

7.2 Second Design Process

We conducted a total of three design iterations before reaching a final design for the HBG prototype; the two first iterations revolved around exploring open-minded ideas, while the third concerned refining a specific design concept. With the same procedure as the first design process, each iteration involved sketching design ideas individually before presenting and discussing them in a subsequent design critique session.

In the first iteration, we wanted to keep an open mind toward new design ideas while still considering that the prototype should be realistic for us to build. In addition, we decided that Must Have and Should Have requirements were essential to include in the concept sketches, while Could Have requirements were optional and “nice to have”. With these directives, the first iteration provided seven distinct design ideas, wherein Figure 7.1 presents four of them. These four sketches present the range of creative ideas that arose from the iteration, including ideas of modular game boards, mini-games, and physical representation of NFTs. After discussing each sketch, we found that the majority lacked important tangible interactions and decided to keep exploring new designs, which led to a second design iteration.

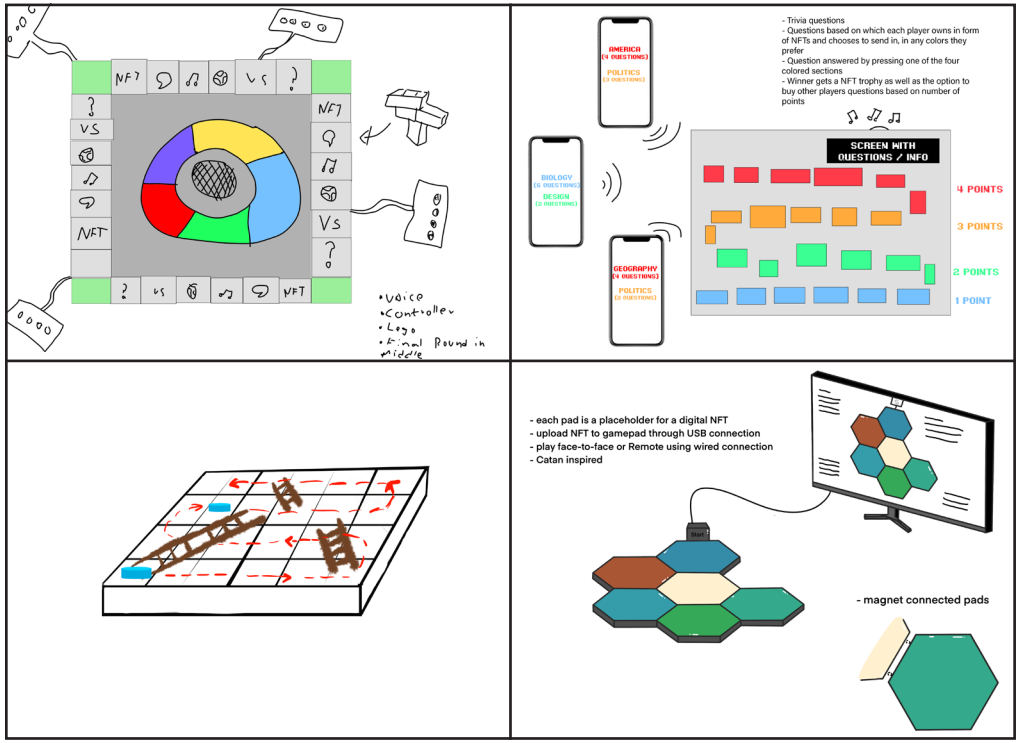


Figure 7.1: *Examples of design sketches during the first iteration.*

In the second iteration, we decided to focus on ways to incorporate NFT characteristics into tangible artifacts that could have meaningful interactions within the context of HBGs. Each group member made several

sketches surrounding this topic, yet we especially found two design concepts inspiring during the design critique; The first sketch (7.2) resembles a game show where players physically interact with a hub and its associated colored buttons to answer questions. When answering correctly, their points are saved in the NFT player token. The second sketch (Figure 7.3) illustrates a physical player token that showcases each player's NFT through a display. The players may also perform diverse actions by interacting with the buttons located on it. To further narrow down our scope, we decided to use these two intrinsic artifacts as a fundamental source of inspiration for the third and final iteration.

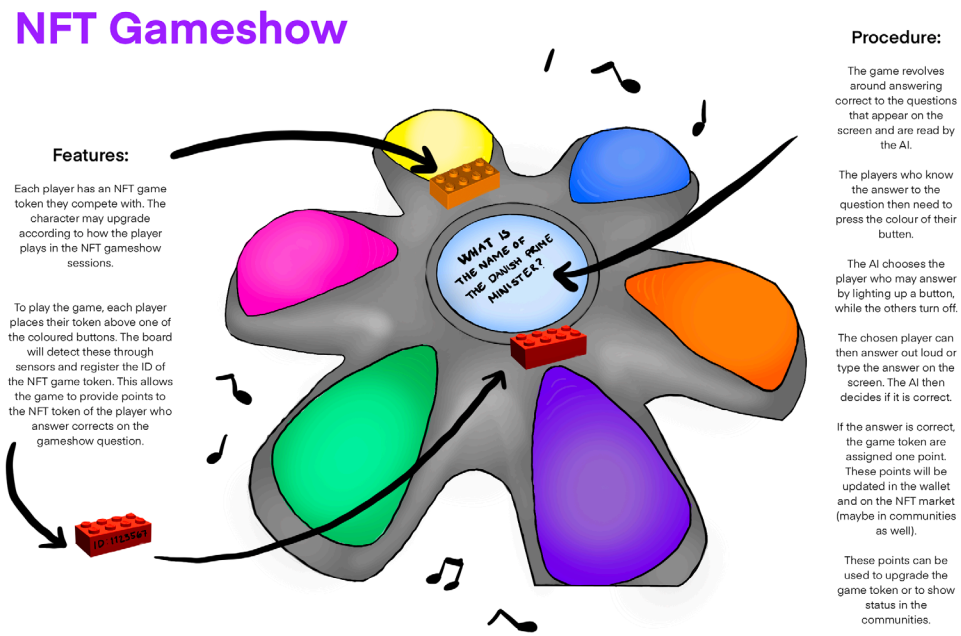


Figure 7.2: *The sketch idea of a hub used as a central place of interaction.*

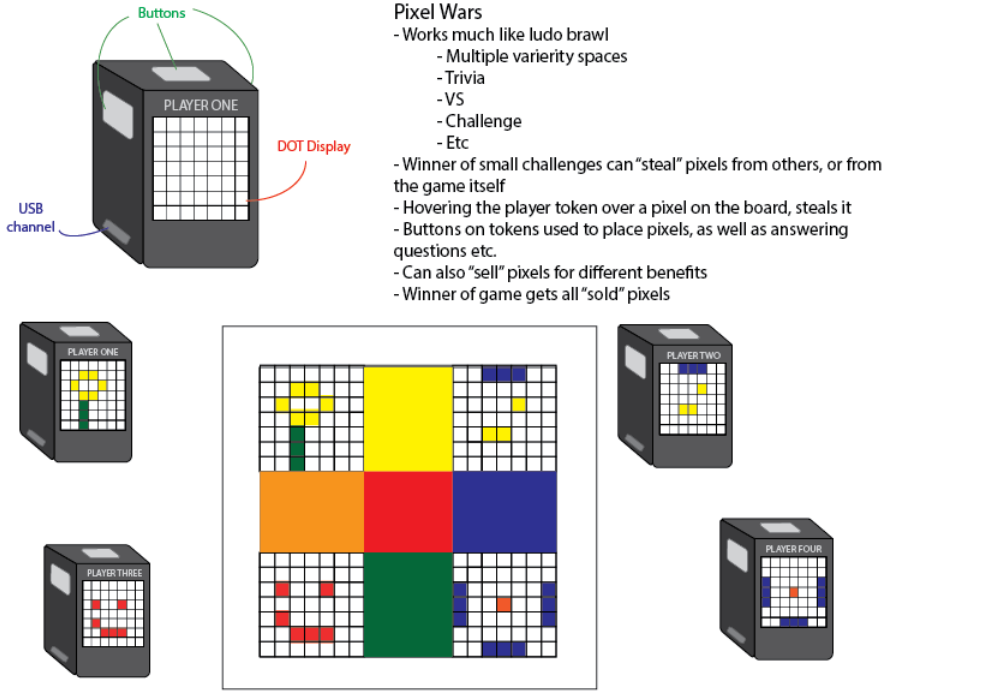


Figure 7.3: *The sketch idea of physical player token that also displays the individual players NFTs.*

In the third and last design iteration, we collectively converged the two previously mentioned sketches into one concrete concept and refined upon this, as viewed in Figure 7.4 and 7.5. Instead of the game hub acting as the HBG itself, we designed it as a central part or a digital host to a physical game board. In this way, we attempted to preserve the material richness of analog board games, while encouraging tangible interactions through the digital components. Furthermore, we wanted the physical game board to be easily changed by another board, giving the option of playing multiple different games in unison with the game hub. This feature would also promote a certain flexibility, otherwise provided by

digital elements compared to physical. Concerning the player tokens, we decided to move the display from the side to the top and install an accelerometer to provide gyroscopic control. The combination of these sketched artifacts led us to our final prototype, called HYBRIDA.

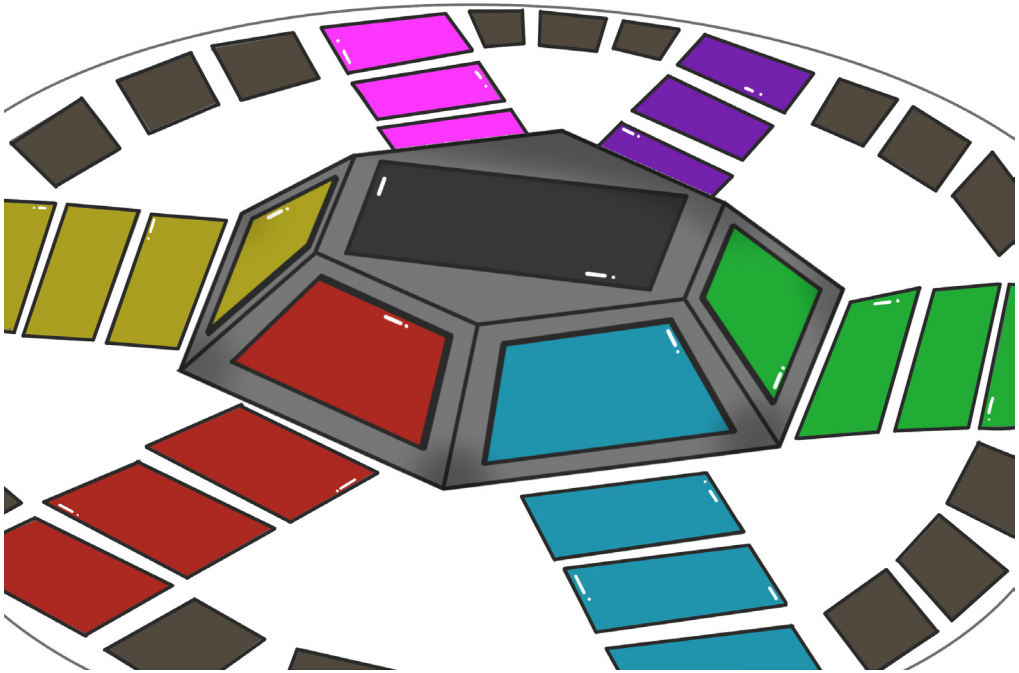


Figure 7.4: *Sketch of the board game hub, and the detachable game board surrounding it.*

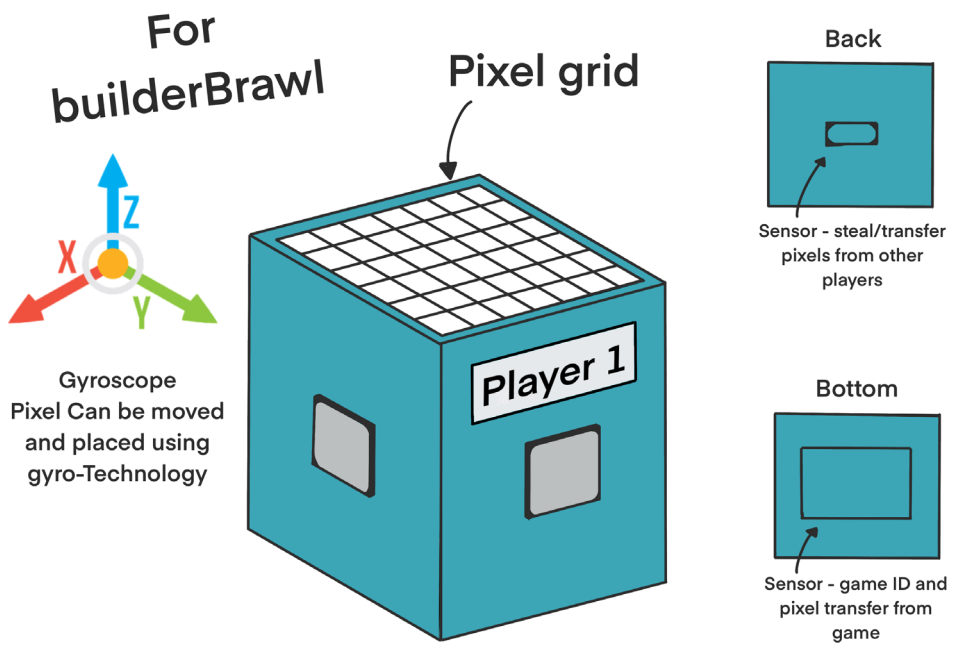
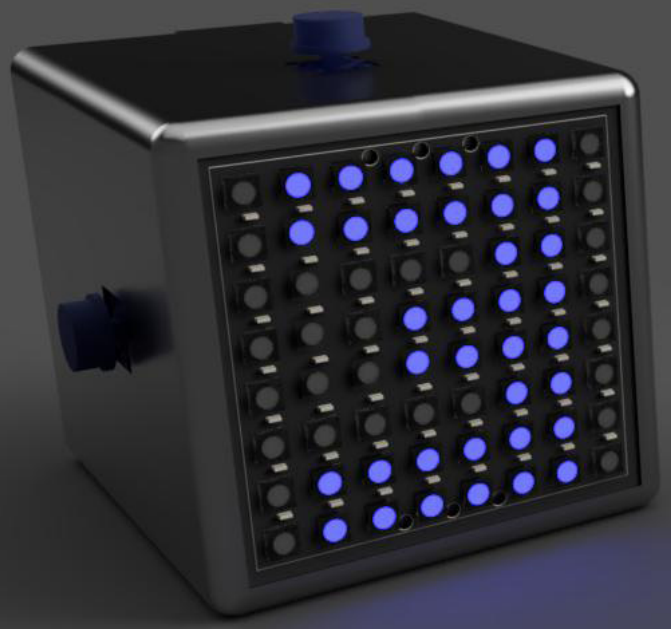


Figure 7.5: *Sketch of the refined player token.*

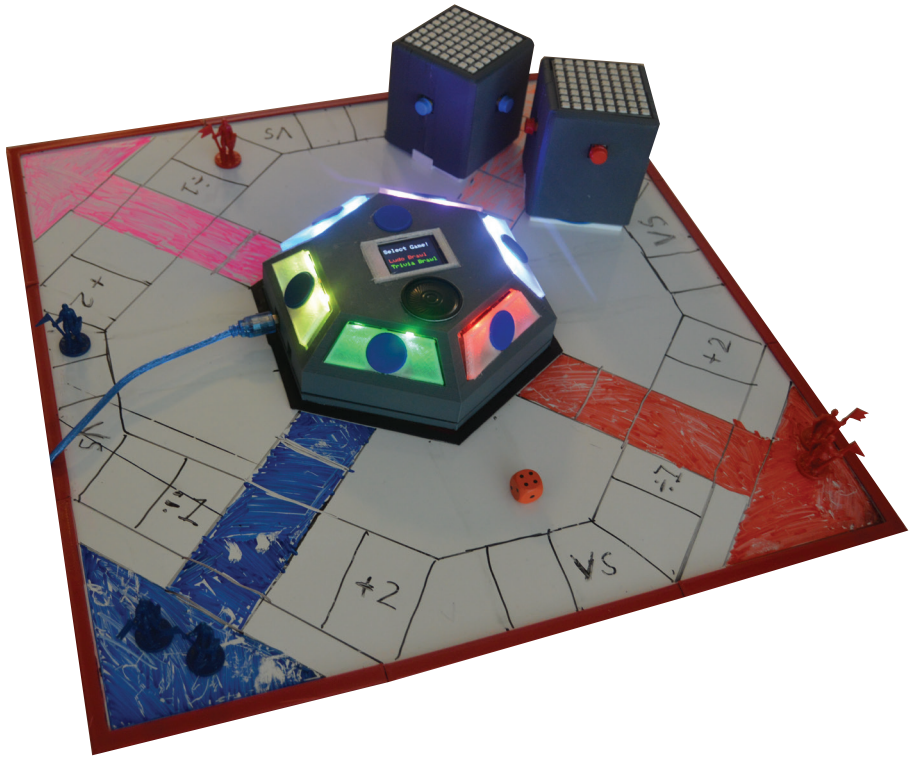


Part 3: Design and Construction

Part 3 presents the construction part of our Master thesis project and contains only Chapter 8. HYBRIDA. In this part, we introduce the finalized hybrid board game and our process of constructing the concept into a functional prototype. Both aspects of hardware and software are explained in deeper detail here.

8. HYBRIDA

In the following chapter, we present our final *hybrid board game* prototype, called *HYBRIDA* (Figure 8.1). HYBRIDA is a HBG because it comprises tangible game components that implement digital technology to enact play. In addition, HYBRIDA integrates four characteristics of NFT technology, specifically *ownership, upgradability, transient*, and *trading*. We begin by explaining each hardware component of HYBRIDA, including their process of creation and technical construction. Next, we introduce parts of the software code for controlling the functionalities of HYBRIDA. Lastly, step-by-step guides of playing the two game modes of HYBRIDA, *Ludo Brawl* and *Trivia Brawl*, are provided.



Figures 8.1: *Hybrida.*

8.1 Hardware Components

The following section describes the hardware of HYBRIDA, which consists of four separate parts: 1) two Game Boards, 2) a Game Hub, 3) two Game Cubes, and 4) several Player Tokens. We dedicate one subsection to three of the hardware components, except for the Player Tokens, wherein we provide a general description of their purpose and functionality in HYBRIDA. The Player Tokens are not explicitly described because their sole purpose in HYBRIDA is to identify and visualize the players' positions on the Game Boards. Thereafter, we delve into the process of creating the parts, including what technical components we used and why these were selected.

8.1.1 Game Boards

HYBRIDA has two Game Boards (Figure 8.2), one for each of the two game modes; Ludo Brawl and Trivia Brawl. Depending on what game mode the players want to play with, they place either (1) the Ludo Game Board or (2) the Trivia Game Board in the middle. At the center of each Game Board, we made a cutout for the players to put the Game Hub in, which controls the game modes and their associated interactions (see Subsection 8.1.2).

We made the Game Boards out of a 50x50 cm wide and 1 mm thick white-covered aluminum sheet, as this material was sturdy, clean, and a cheap alternative (Figure 8.3). Using an aluminum plate would also allow us to draw and easily erase Game Board designs on its surface using whiteboard markers. Furthermore, we covered the sides and bottom of the Game Board with 3D-printed PLA plastic, avoiding injuries from the sharp aluminum edges.

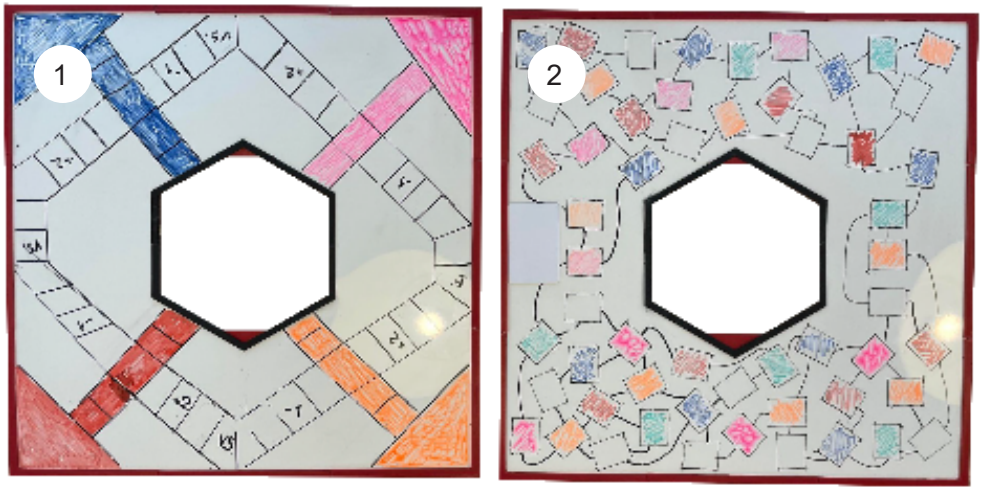


Figure 8.2: *The two Game Boards constructed to play with HYBRIDA, where the left is Trivia Brawl and the right is Ludo Brawl.*

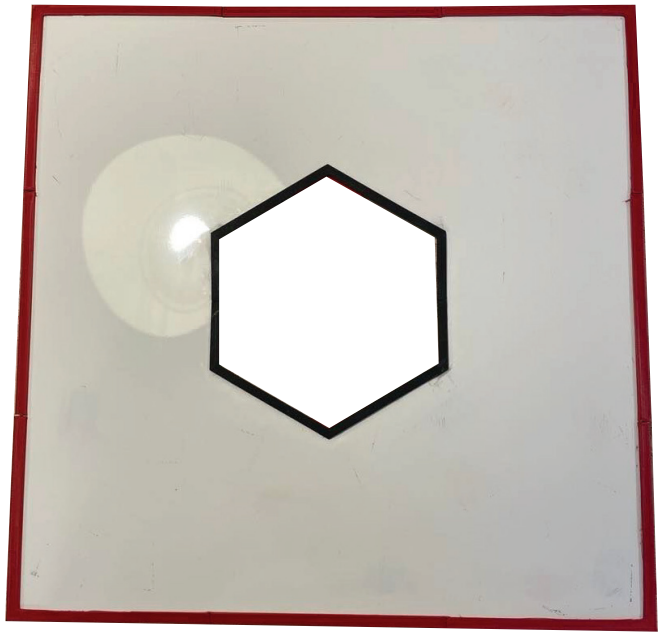


Figure 8.3: *The aluminum plate used to create each of the two Game Boards.*

8.1.2 Game Hub

The Game Hub is an interactive device that manages the HYBRIDA game modes and the interaction with the players during time of play. To support these functionalities, the Game Hub includes a wire connection, a screen, and six Hub-buttons, as presented in Figure 8.4. (1) As the Game Hub acts as the “gamemaster” in HYBRIDA, the players put the device at the center of the Game Board and connect its cable to a power outlet. This prompts the Game Hub to prepare and initiate play. (2) We implemented a screen atop the Game Hub to easily convey important information about the gameplay and feedback regarding the state of HYBRIDA. (3) The six Hub-buttons placed on each side of the Game Hub, enable the players to directly interact with HYBRIDA, such as choosing a game mode or Trivia subject category. By using colored-lighting buttons instead of plain ones, we aimed to provide additional feedback regarding completed actions and game states. These buttons also support interactions with the Game Cube, as we explain further in subsection 8.1.3.

Figure 8.4: *The Game Hub placed on the Trivia Board, where the screen displays the initial stage of HYBRIDA.*

Technical Components

The Game Hub incorporates seven types of technical components (Figure 8.5). (1) An *Arduino UNO microcontroller* that acts as the control center, ensuring that the code transfers from the computer to the remaining four technical components. (2) A *WS2812 LED strip* with 12 LEDs that displays colored lights inside the Hub-buttons. (3) Seven *RFID tags* that enable the Game Cubes to interact with the Hub-buttons and read data from them in terms of pixel-transfers. (4) A *1.8 LCD TFT Display* that presents information and provides feedback during time of play. (5) Six *12x12 mm tactile buttons* that enable the players to push in the Hub-buttons. In addition to said components, we had a *5W speaker* and an *LM386 Amplifier* to provide additional audio feedback with enhanced sound throughput. However, these modules were not implemented due technical issues of libraries being incompatible with the one necessary for the Speaker to function. All technical components are connected through jumper wires, as viewed in the schematic of the Game Hub's technical setup (Figure 8.6).

1) Arduino UNO micro-controller

2) WS2812 LED strip

3) RFID tags

4) 1.8 LCD TFT Display

5) 12x12 mm tactile buttons

Figure 8.5: *The five different technical components used for the Game Hub.*

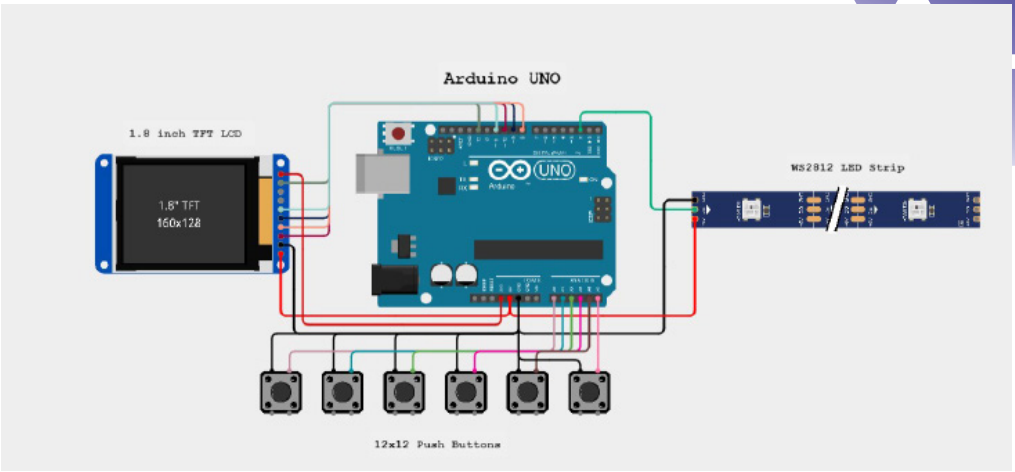


Figure 8.6: *How the technical components of the Game Hub are connected through jump wires.*

Hardware Construction

The hardware of the Game Hub consists of four separate elements that were custom-made and 3D-printed in PLA plastic, including three kinds of structural parts and six Hub-buttons. We made the three structural elements in gray PLA plastic to make the Game Hub aesthetically appealing and the colored-lighting Hub-buttons prominent in the design. The *bottom segment,* viewed in Figure 8.7, we designed to contain six essential technical components: (1) A cut out for the Arduino and (2) one slot for a larger sized battery, and (3) one for a smaller sized battery. In this way, we could hide the technical components inside the Game Hub and allow portability. The three remaining slots in the bottom segment were made for other technical components that during testing became either obsolete or incompatible with the setup, thus removed from the prototype. We decided to keep this design of the bottom segment despite not using all slots as it would save us time and resources from printing a new one.

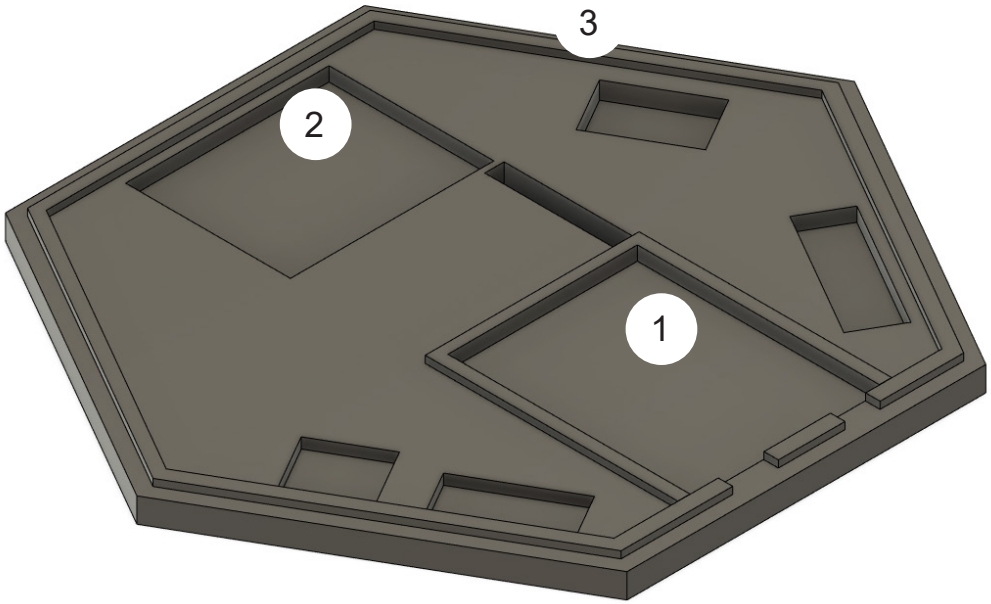


Figure 8.7: *The bottom segment of the Hub, which is one of three structural parts.*

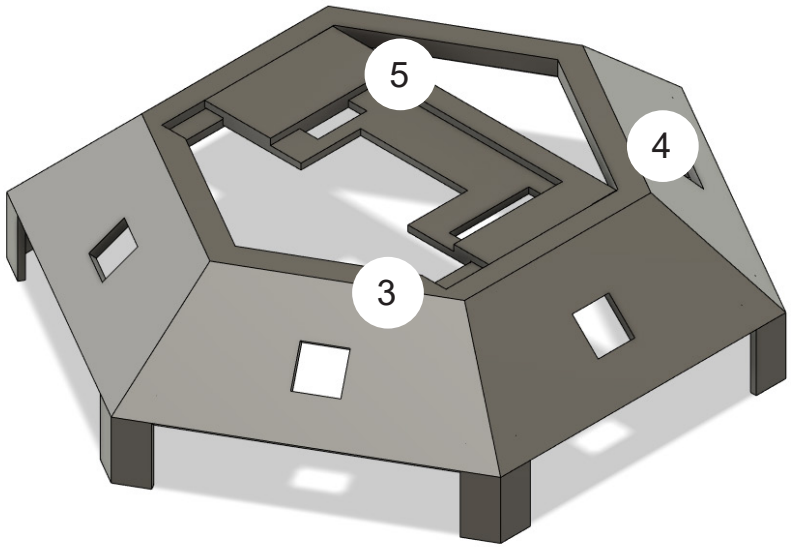


Figure 8.8: *The skeleton segment of the Hub, which is one of three structural parts.*

The second part of the Game Hub structure is the skeleton (Figure 8.8), which we designed to hold all technical components in their correct positions: (4) In the holes on each side, we glued the tactile buttons to ensure proper placement underneath the customized Hub-buttons. (5) We positioned the LED strip around the top edges of the skeleton, which was possible due to the spacious design of the outer shell (see next paragraph). (6) The cutout on top kept the LCD screen in place.

The third and last structural part is the outer shell (Figure 8.9), which encapsulates all the technical components of the Game Hub. Considering the placement of technical components in the skeleton, we made the following cutouts in the outer shell: (7) a hole on top to visualize the LCD screen, (8) a smaller round hole to place an RFID tag, and (9) a wider round hole to position the Speaker module. (12) We also made a cutout on the lower side to easily connect the Arduino to a power outlet and enable data transfers from the computer. (11) Finally, we made six holes for each customized Hub-button, enabling us to attach them to the tactile buttons placed in the skeleton.

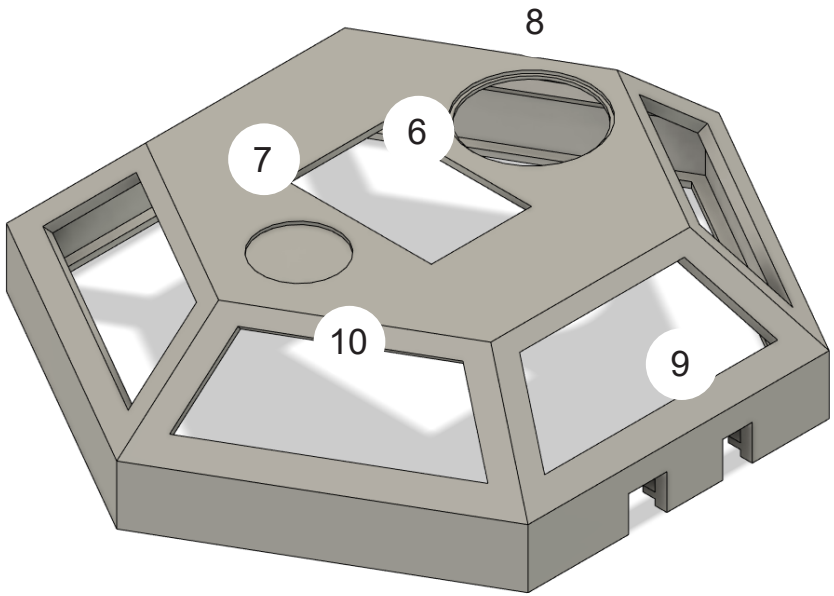


Figure 8.9: *The outer shell of the Hub, which is one of three structural parts.*

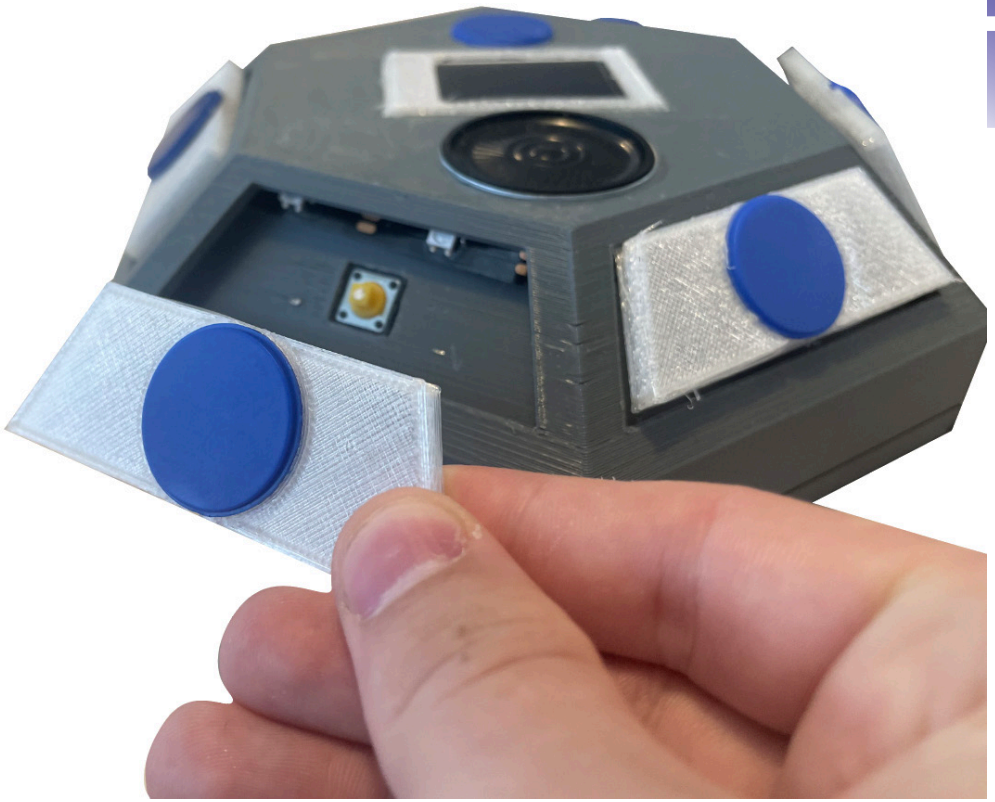


Figure 8.10: *The custom-designed button for the Hub.*

Besides the three structural parts of the Game Hub, we 3D-printed six individual custom-designed buttons in transparent PLA plastic (Figure 8.10). We chose a transparent material to enable the colored LED lights to shine through. On the front side of each Hub-button, we glued an RFID tag that made it possible for the Cube to register pixel colors corresponding to their lights.

8.1.3 Game Cube

The Game Cube (Figure 8.11) is the main component used by the players during time of play. Each player is in possession of a Game Cube and uses it for mainly two purposes; 1) acquiring or losing pixel dots through interaction with the Game Hub, and 2) playing mini-games against other players. To enable these features, the Game Cube consists of four main components: (1) a LED Matrix, (2) three tactile buttons, (3) a RFID scanner, and an accelerometer that is placed inside the Game Cube.

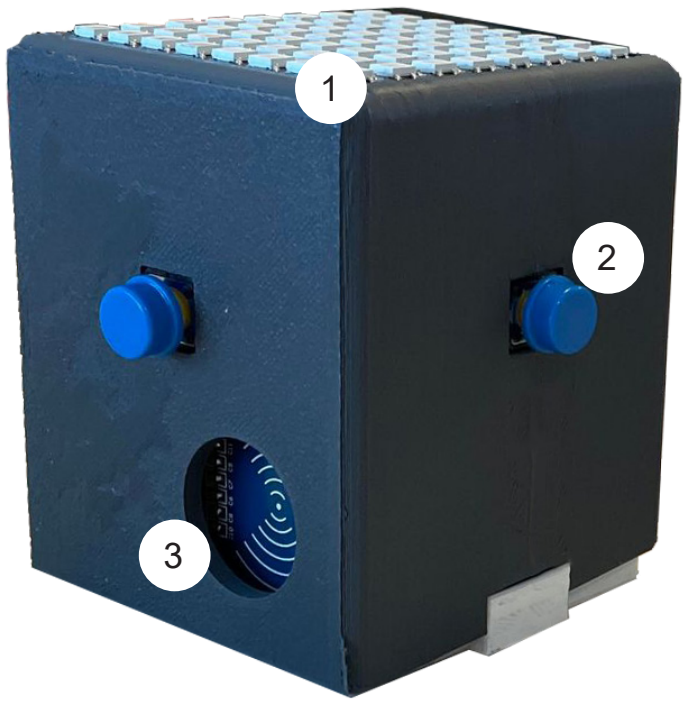


Figure 8.11: *The Game Cube.*

Technical Components

The Game Cube consists of six types of technical components, as introduced in Figure 8.12: (1) An *Arduino Nano* that acts as a microcontroller, ensuring that any technical component operates according to the written software code. (2) A *8x8 64 LED Matrix WS2812* that displays the players' NFT and provides an interface for playing the mini-games. (3) A *RFID RC522* that registers the RFID tags located on each Hub-button, enabling players to acquire or deposit a specific colored pixel dot from the pix-dot display. (4) Three *12x12 mm tactile buttons* to support interactions with the pixel-dot display and the mini-games, such as securing the position of pixel dots. (5) An *ADXL335 accelerometer* that registers when the players tilt their Game Cube in any direction, an interaction used to place pixel dots and compete in the mini-games. (6) Lastly, an 9V Battery to power the Arduino Nano. A schematic of the Game Cubes technical setup can be found in figure 8.13.

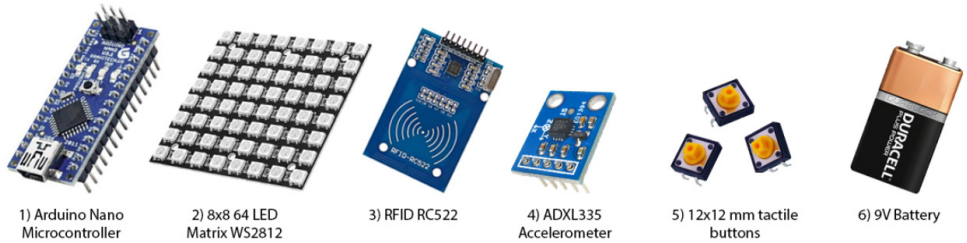


Figure 8.12: *The six different technical components used for the Game Cube.*

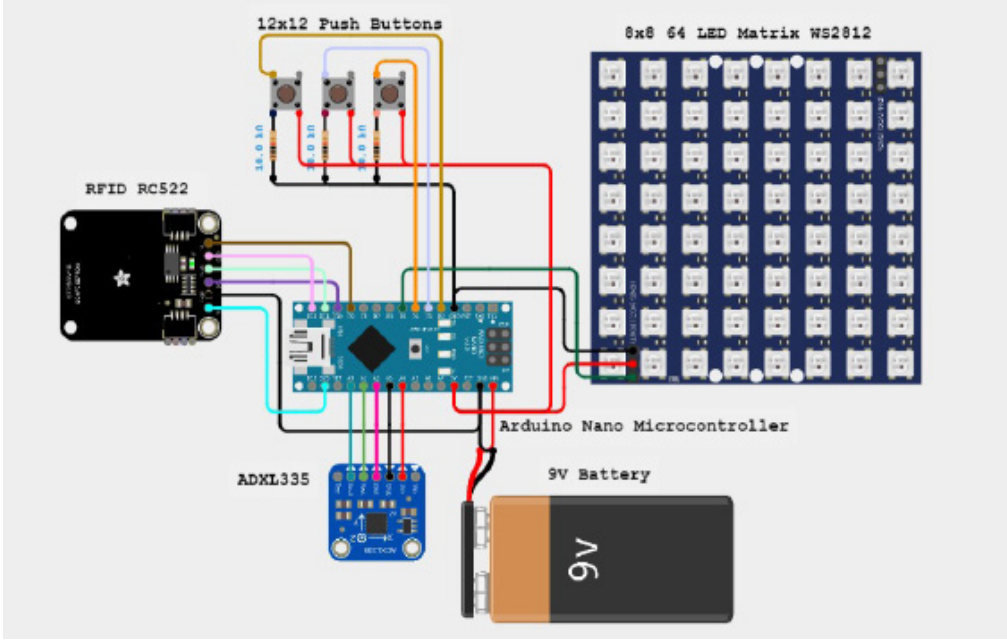


Figure 8.13: *How the technical components of the Game Cube are connected through jump wires.*

Hardware Construction

The hardware of the Game Cube consists of three structural parts; two *shell segments* and a *skeleton*. We 3D-modeled and printed each part in gray PLA plastic to match the Game Hub, creating consistency in the game design. The outer shell, viewed in Figure 8.14, was sliced into two individual segments to ease the implementation of technical components inside the Game Cube. Furthermore, we made a square hole in the middle of three shell sides to install the tactile buttons: (1) One hole positioned towards the player, and (2) the remaining two holes were placed on each side of the player. (3) An additional round hole was created on the left side of the shell, enabling the RFID RC522 to register potential RFID tags through it. (4) On top of the outer shell we made a cutout to keep the LED Matrix in its correct position, including a square hole for wiring the display to the Arduino Nano.

The third and last piece of the Game Cube is the skeleton (Figure 8.15), which comprises multiple slots to keep the individual technical components in place. This was especially necessary due to players having to tilt the Game Cube during play. (1) We made a small indent for the RFID RC522 to slide in, ensuring that the module would stay in the exact position after attaching the outer shell and the players moving the Cube. (2) A tiny slit on top of the middle pillar to position the ADXL335 accelerometer. (3) For the 9V battery, we created a holster to put it in. (4) Lastly, we placed the Arduino Nano microcontroller and its USB input in a small cutout at the bottom to give entrance for an USB cable. In addition, the pins on the microcontroller were hugged around the middle pillar, keeping it steady.

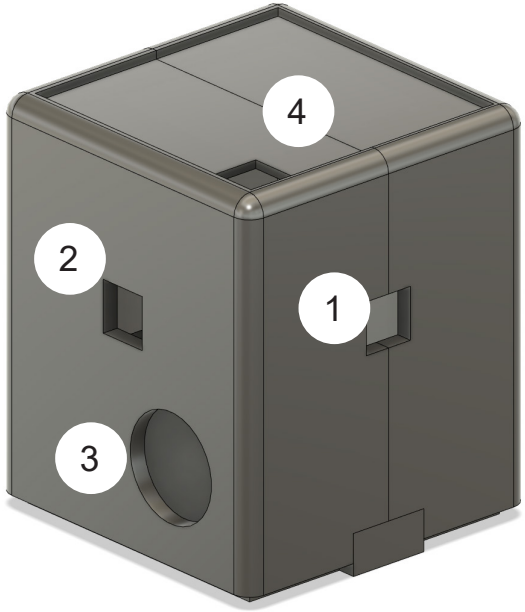


Figure 8.14: *3D model of the outer casing of the Game Cube.*

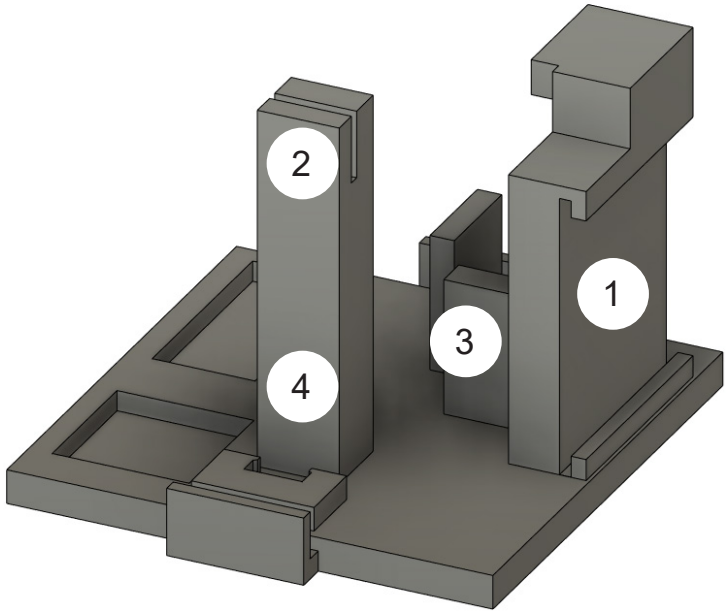


Figure 8.15: *3D model inner skeleton of the Game Cube.*

8.2 Software

The purpose of the subsequent section is to give an understanding of how we made the software of HYBRIDA. Without going into too many technical aspects, we explain the software created to connect the technical setup of the Game Hub and Game Cubes, making each component interactive. We coded the software in Arduino IDE using the programming language C++. While most of the code is custom-made, we also applied a few pre-written libraries to ease the interaction with specific technical components. The succeeding section provides individual descriptions of the Game Hub and Game Cube software, introducing a simplified explanation of their logic, essential code snippets, and the implemented libraries.

8.2.1 Game Hub

To provide a general overview of the logic behind the Game Hub functionality, we made a flowchart, as presented in Figure 8.16. (1) When connecting the Game Hub to a power outlet, the device initiates a startup sequence, while the Hub-buttons light up in a pre-defined sequence. (2) After startup, the Game Hub awaits input from the player to press either the game mode Ludo Brawl or Trivia Brawl. (3) If the players select Ludo Brawl, all lights turn red to indicate that the Game Hub launches this game mode. While Ludo Brawl primarily focuses on interactions with the Cube, the Game Hub remains passive until the round of Ludo Brawl is over. (4) If the players select Trivia Brawl, all lights turn green to communicate that the Hub prepares for this game mode. (5) After initiating Trivia Brawl, the screen presents all six Trivia categories for players to choose from when landing on a colored field. Once they select a category, a Trivia question appears on the screen and two possibilities can occur. (6) If the player knows the question, they may press the red button after answering. (7) However, if the player does not know the answer, they can press the green Hub-button and receive a hint from the Game Hub. Having provided an answer to the trivia question, the player may push the red button to check whether they answered correctly. (8) When pushing the red answer button, the screen presents the answer in five seconds before returning the players to the category display.

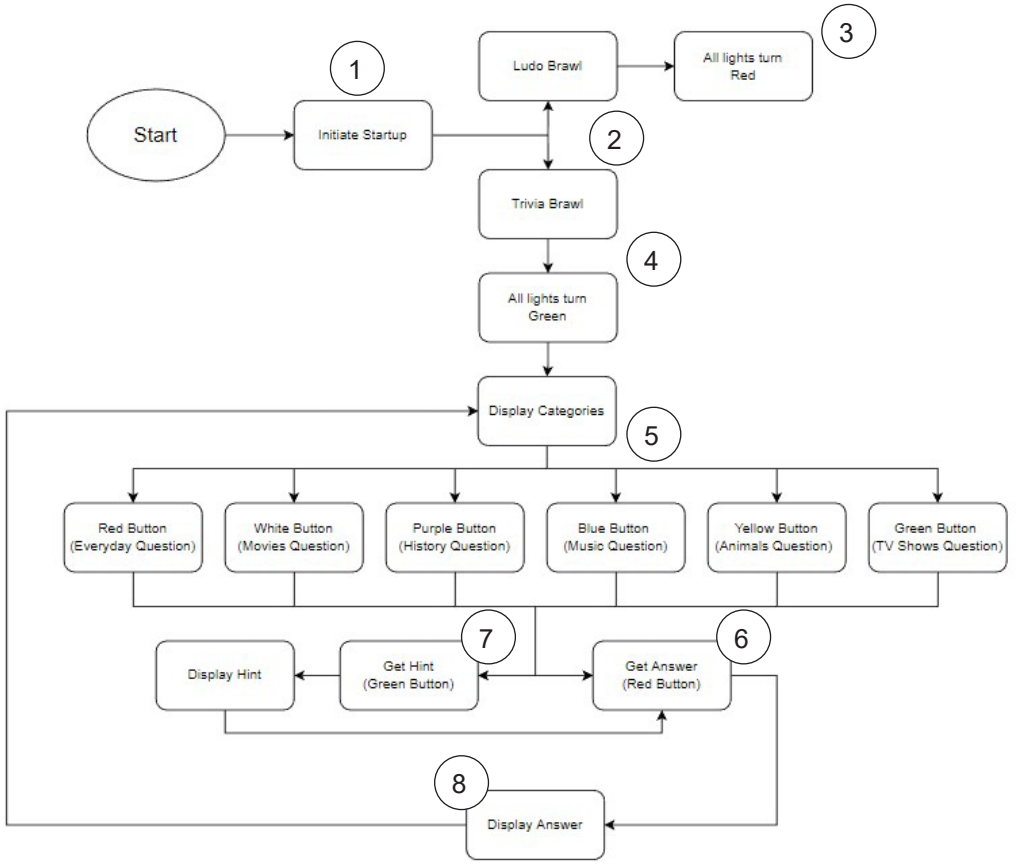


Figure 8.16: *Simplified flowchart of the Game Hub.*

Codes and Libraries

Creating the software functionality of the Game Hub, 762 lines of code were written in total. These code lines included the function of selecting a game mode and the Trivia Brawl mode itself. To give an example from the Game Hub software, we explain the code made for selecting a category of questions during the Trivia Brawl game mode and how the LCD TFT display changes its text accordingly (Figure 8.17-8.18): When Trivia Brawl is initiated on the Game Hub, the code goes into a loop that constantly checks whether one of the six Hub-buttons is pressed. (1) If one Hub-button is pressed, in this case the red, the code goes into an if-statement that defines the integer `QuestionComplete` as equal to one. This number is used to determine whether the program is in the correct loop. (2) In addition, the `TFTscreen` function assigns a designated font color and font size for the text on the display. (3) Once the boundaries are defined, the code goes into a while-loop, wherein a function named `RedQuestionNumber` determines if the Trivia question has been presented on the LCD TFT display before. If the question has been introduced before, the code continues to the next question until finding one that has not. (4) The function then increments `QuestionComplete`, meaning that the integer increases by one, to tell the system that the question has been processed. After these codelines have been executed, the LCD TFT display presents the appropriate question while also calling the function `Options()`. This function makes the text 'Hint' and 'Answer' appear in red and green font color respectively, as shown in Figure 18.18.

The abovementioned example introduces how we custom-made and coded an important part of the Game Hub software. However, to mitigate the coding process we also utilized three libraries. The first library we implemented was *SPI.h,* short for *Serial Peripheral Interface*, which enabled the microcontroller to interact with other SPI components like the LCD TFT display [3]. The second library, called *FastLED.h*, we used to control the LEDs on the LED strip, connected to the Game Hub [1]. The third and last library was *TFT.h*, which allowed us to draw text, display images, and shapes onto the TFT LCD display [4].

```
170  if (buttonStateRed == LOW) {
171    int QuestionComplete = 1;
172
173    TFTscreen.stroke(255, 255, 255);
174    TFTscreen.setTextSize(1);
175
176    while (QuestionComplete == 1) {
177      if (RedQuestionNumber == 0) {
178        QuestionComplete = 2;
179        TFTscreen.background(0, 0, 0);
180        TFTscreen.text("What English word is used", 6, 35);
181        TFTscreen.text("about the exits at an", 6, 50);
182        TFTscreen.text("airport from which you", 6, 65);
183        TFTscreen.text("board your plane?", 6, 80);
184        Options();
```

Figure 8.17: *Code snippet that displays a question from Trivia Brawl.*

```
756
757 void Options() {
758   TFTscreen.stroke(0, 255, 0);
759   TFTscreen.text("Hint", 6, 100);
760   TFTscreen.stroke(0, 0, 255);
761   TFTscreen.text("Answer", 6, 110);
762 }
```

Figure 8.18: *Code snippet of the function Options(), displaying Hint and Answer on the screen.*

8.2.2 Game Cube

Similar to the Game Hub, we provide a flowchart to present the internal logic of the Game Cube software, as seen in Figure 8.19: (1) While the Game Cube starts up, it examines the LED Matrix and clears any potential pixel dot lighting up. (2) Thereafter, the Game Cube stays in a standby mode, awaiting input from the player. (3) If the player presses the button pointing towards them, the Game Cube launches the first mini-game in a row of three types of games. The next time the player initiates a mini-game, they play the second game and then the third. When the Game Cube has launched all three mini-games, it restarts and returns to the first mini-game again. (4) After the players complete a mini-game, the Game Cube resumes the standby mode and awaits new input. (5) If the RFID RC522 placed on the side of the Cube registers one of the seven potential tags, an examination begins wherein two possibilities can occur. (6) If it reads one of the six colored tags on the Hub-buttons, a pixel dot with the corresponding colored light appears on the LED Matrix. (7) Thereafter the player may position and move this pixel dot around the LED Matrix by tilting the Game Cube, which the ADXL335 accelerometer registers. (8) When satisfied with the pixel position, the player click the middle button to confirm, making the Game Cube internally save its placement before proceeding to the standby mode. (9) However, if the RFID RC522 reads the deposit tag on top of the Game Hub, the last-placed pixel by the player gets deleted from the LED Matrix.

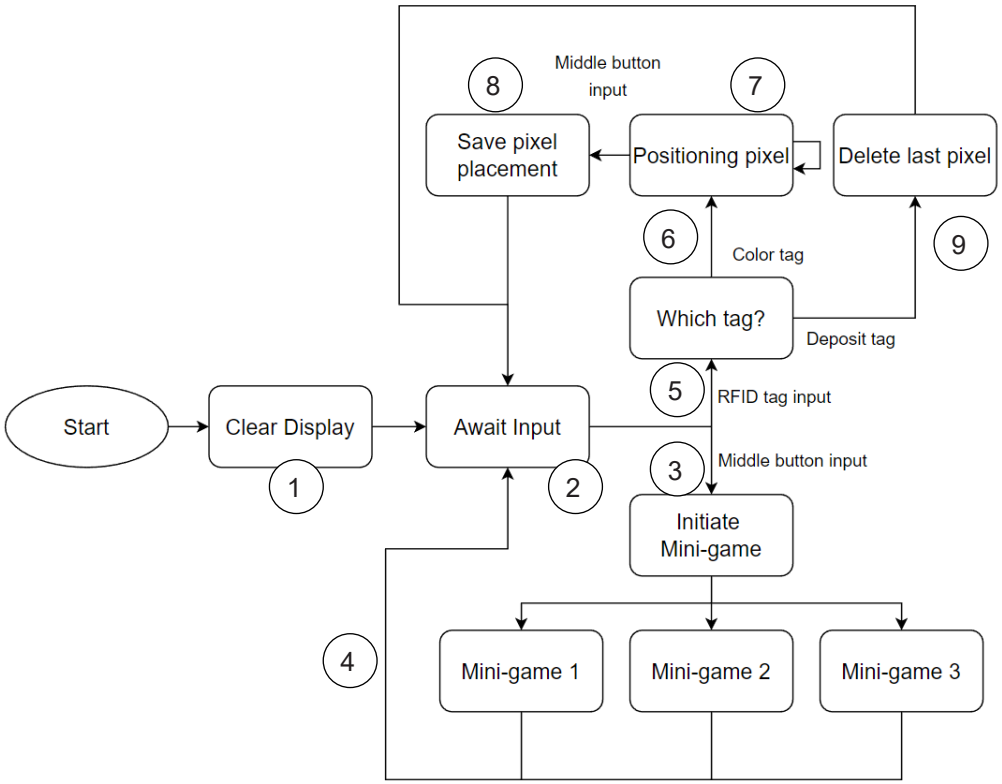


Figure 8.19: *A simplified logic flowchart of the Game Cube).*

Codes and Libraries

For the Game Cube software, 1010 lines of code were written in total. These code lines encompass functions like reading and identifying RFID tags, placing colored dots and saving their position on the LED Matrix, and initiating mini-games. To exemplify the Game Cube software, we introduce and describe code snippets for placing and saving colored dots on the LED Matrix (Figures 8.20-8.22): In the code, the LED Matrix is represented by a global array of integers that depicts the specific NFT image of the players (Figure 8.20). Each integer within the array represents an individual LED on the corresponding LED Matrix, while the value of the integer signifies a color or state; if the integer is equal to 0, the LED is turned off, 1 is red, 2 is white, and so forth. When the Game Cube initiates, these are automatically set to 0, giving an empty NFT.

```
27  int pixelArray[] = {
28    0, 0, 0, 0, 0, 0, 0, 0,
29    0, 0, 0, 0, 0, 0, 0, 0,
30    0, 0, 0, 0, 0, 0, 0, 0,
31    0, 0, 0, 0, 0, 0, 0, 0,
32    0, 0, 0, 0, 0, 0, 0, 0,
33    0, 0, 0, 0, 0, 0, 0, 0,
34    0, 0, 0, 0, 0, 0, 0, 0,
35    0, 0, 0, 0, 0, 0, 0, 0,
36
37  };
```

Figure 8.20: *Code snippet of the global array depicting the players NFT.*

Moreover, if a player wants to add a colored dot to their NFT image, the function `PixelPlus` is called, as seen in Figure 8.21. Depending on which RFID tag the RFID RC522 has read, the color codes of the corresponding Hub-button are passed into the function (line 423). Thereafter, the function named `Placement` is called, which returns a value of either *Left, Right, Up*, or *Down* (line 434). These values rely upon how the player is tilting the Game Cube and, in turn, the accelerometer. When either of the three values are returned, the position of the colored dot moves accordingly, by changing the value of the integer variable named `currentPlacement`.

```
423 void PixelPlus(int R, int G, int Y, int Array) {
424
425
426   boolean settingPixel = true;
427   int currentPlace = 0;
428   pixels.setPixelColor(currentPlace, pixels.Color(R, G, Y));
429   pixels.show(); // This sends the updated pixel color to the hardware.
430   while (settingPixel == true) {
431     int rightplus = 8;
432     int leftminus = -8;
433
434     if (Placement() == "Up") {
435       if (pixelArray[currentPlace + 1] == 0) {
436         pixels.setPixelColor(currentPlace, pixels.Color(0, 0, 0));
437         currentPlace++;
438         pixels.setPixelColor(currentPlace, pixels.Color(R, G, Y));
439         pixels.show(); // This sends the updated pixel color to the hardware.
440         delay(1000);
441       }
```

Figure 8.21: *Code snippet of the function PixelPlus, used to move colored dots on LED Matrix.*

Lastly, when the player wants to place the colored dot in its current position, they press the middle button, as shown in Figure 8.22, line 492. Subsequently, the position and color type are parsed into the global array previously mentioned (line 499). In addition, the position of the colored dot is saved into a global integer called `lastPixel` (line 501), which is used when the function of depositing a colored dot is called.

```
    if (buttonStateM == HIGH) {
      Serial.println("Set");
      pixels.setPixelColor(currentPlace, pixels.Color(0, 0, 0));
      pixels.show();
      delay(1000);
      pixels.setPixelColor(currentPlace, pixels.Color(R, G, Y));
      pixels.show();
      pixelArray[currentPlace] = Array;
      settingPixel = false;
      lastPixel = currentPlace;
      delay(1000);
    }
  }
}
```

Figure 8.22: *Code snippet of the function PixelPlus, which shows the process of saving the positions of pixel dots in an array.*

Next, we explain the three libraries used for the Game Cube software and their intended purpose within this context. As with the Game Hub, we implemented the library of *SPI.h* for the microcontroller to properly interact with other SPI devices, such as the RFID RC522 [3]. The second library we applied was *MFRC522.h*, which is a library that simplifies the reading and writing of data from the RFID RC522 [1]. In the Game Cube code, we use said library to read RFID tags and extract the unique ID of each tag, leading to a specific action predefined by us. Lastly, we integrated the library of *Adafruit_NeoPixel.h*, which contains functions for controlling addressable LEDs, like the ones present on the LED Matrix [9]. We use this library to specify the state of each LED, such as their light intensity, RGB colors, and their on/off state.

8.3 Step-by-step playing guide

Based on the hardware and software construction of HYBRIDA, the subsequent section provides a step-by-step guide on how to play the game modes of Ludo- and Trivia Brawl. This guide showcases how the individual components operate by themselves and interact with each other during time of play. We begin explaining how to set up HYBRIDA, as this is the initial step of playing. Thereafter, a walkthrough of Ludo Brawl and Trivia Brawl is given followed by descriptions of three mini-games associated with the Ludo Brawl gameplay.

8.3.1 Setting up HYBRIDA

Before being able to play HYBRIDA, the players must put together the physical game setup. To begin with, the players have to decide which game mode they want to play and pick the corresponding Game Board (Figure 8.23). After placing the preferred Game Board on a table or similar surface, they put the Game Hub in its designated spot in the middle of the board and connect it to a power outlet. Once connected, the Game Hub initiates a startup sequence, indicated with the lights in the Hub-buttons turning on. Next, the screen provides the players with the option of selecting Ludo Brawl or Trivia Brawl, which are represented by one color each; red and green respectively (Figure 8.24). To choose a game mode, the players have to press the Hub-button with the corresponding color as the board game they prefer. The chosen game must also conform with the Game Board placed under the Hub, as different instructions and functions will transpire. While the players' Game Cube are autonomous, no setup or connection between the cubes or the Hub is needed. Lastly, the players have to put their Player Tokens on the designated start position of the selected Game Board, such as in the corners of Ludo Brawl.

Figure 8.23: *The two Game Boards, Ludo Brawl and Trivia Brawl.*

8.3.2 Ludo Brawl

The following walkthrough explains the gameplay of Ludo Brawl and provides specific in-game examples (Figure 8.25); (1) When the players choose Ludo Brawl on the Game Hub, all lights turn red to indicate that the board game is selected and prepared for play. (2) The starting player may then roll the die and (3) move their Player Token with corresponding steps across the fields of the Game Board. In this case, the red player landed on “+2”, which means they are allowed to acquire two colored pixels of their choice. (4) To do so, the player places their Game Cube against one of the colored Hub-buttons on the Game Hub, (5) resulting in a corresponding colored pixel appearing on their LED Matrix. (6) By tilting the Game Cube, the player can position the colored dot on the LED Matrix and confirm its position by pressing the middle button. (7) Later in the game, the red player lands on a “VS” field, which means that all players are to compete against each other in a mini-game (subsection 8.2.3). Unfortunately, the red player lost the mini-game and (8-10) must deposit their last-collected pixel by placing their Game Cube on top of the Game Hub. If he had won, then he was allowed to gain two colored pixels, much like that of the “+2” field. If a player were to land on a “-1”, the same action of depositing a pixel is made. (11) Even later in the game, the blue player lands on top of a red Player Token, (12) which means that the red Player Token is to be sent back home where he started. However, the red player has luck on his side, and manages to bring all three of his Player Tokens around the board and into the safe area, which means he has won. The winner is allowed to pick three colored pixels of his choice as a reward.

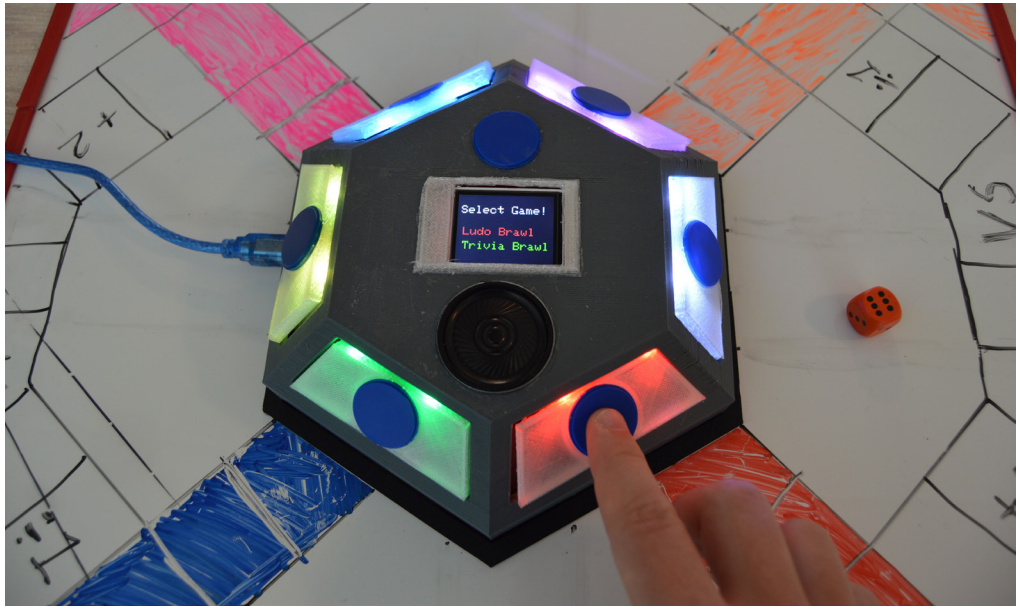


Figure 8.24: *A player initiating Ludo Brawl on the Game Hub.*

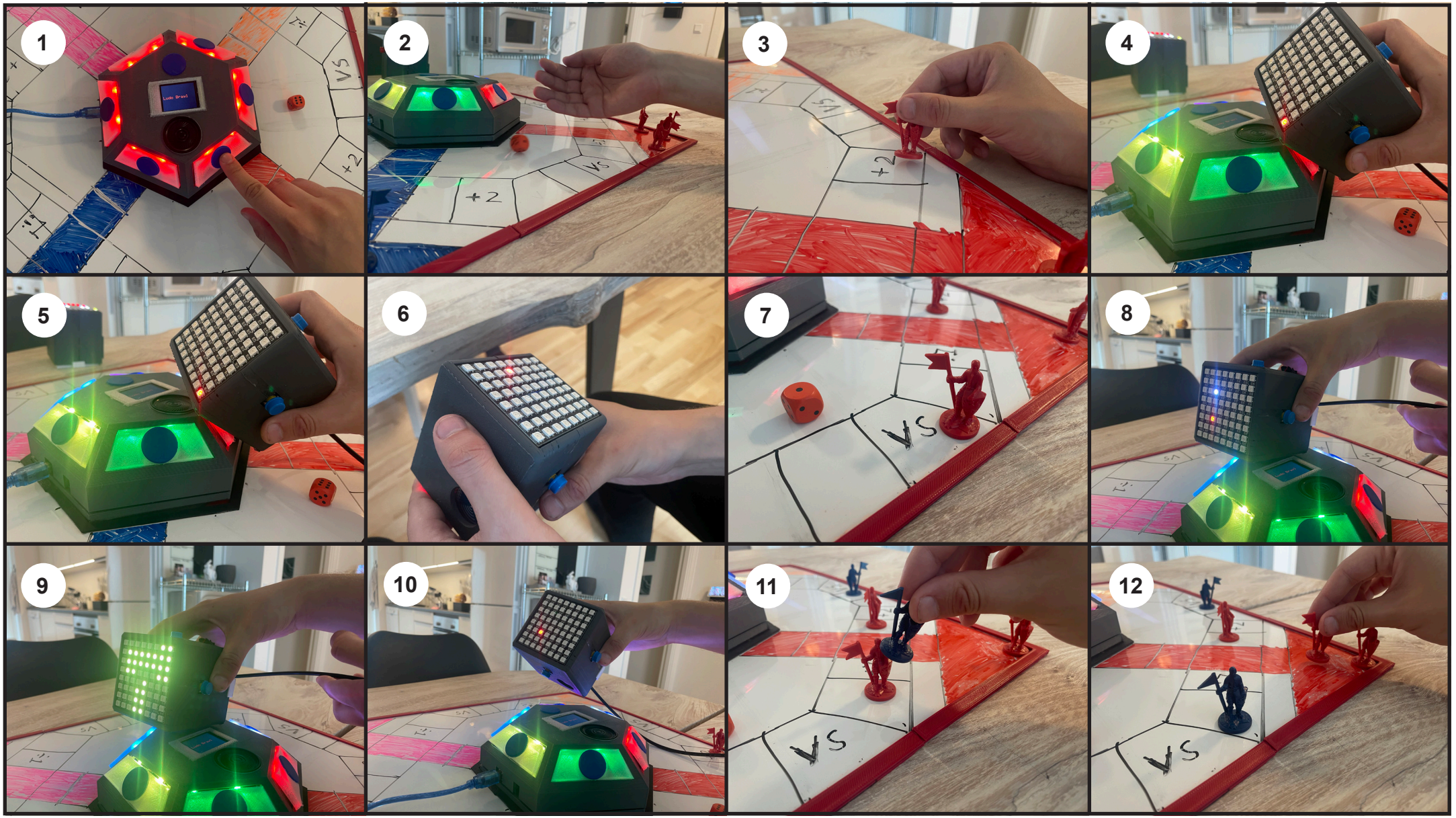


Figure 8.25: *Step-by-step guide of Ludo Brawl.*

8.3.3 Minigames

Three mini-games have been coded and implemented into the Game Cubes: 1) *Countdown*, 2) *Guess the Dots*, and 3) *Quick Snake*. Whenever a player initiates a mini-game by pressing the middle button, the "VS" symbol appears on their LED Matrix before one of the three games begins (Figure 8.26). The first mini-game the players encounter is *Countdown* (Figure 8.27), which concerns players having to press a button precisely after five seconds: When initiated, the LED Matrix on each Game Cube will count down from (1) five seconds, (2) only showing the first two digits. From here, the players are to count down by themselves internally and click the middle button located on their Game Cube, when they think the timer hits zero. After players have clicked their button, the LED Matrix shows how many milliseconds they are from zero. Two full rows indicates one full second, and (3) the green color represents if the player pressed the button when the timer was before five seconds had passed, (4) meanwhile red indicates if the player pressed the button after five seconds had passed. The player with less pixel dots on their display wins, as they were closest to zero when pressing the button.

Figure 8.26: *The "VS" symbol appearing when initiating a mini-game.*

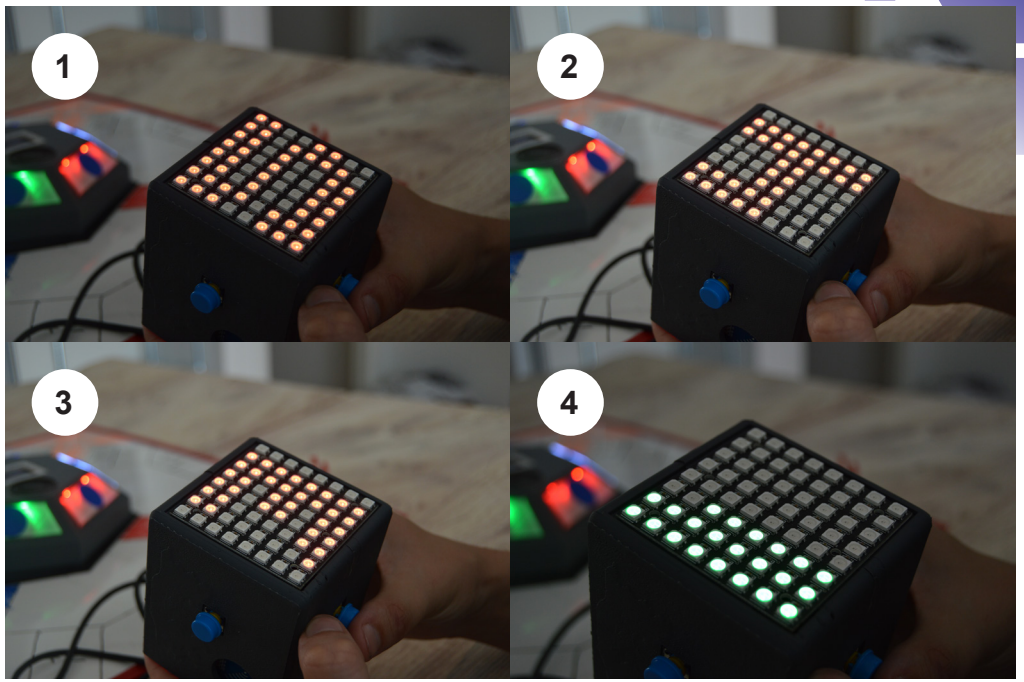


Figure 8.27: *The mini-game called Countdown.*

The second mini-game the players encounter is *Guess the Dots* (Figure 8.28), which concerns the players having to guess which of two colors has the majority of the dots displayed; (1) When initiated, the LED Matrix on each Game Cube will show a predefined number of green and red dots that will be placed randomly. (2) After four seconds, the LED Matrix shows the color green and red on the right and left side of the LED Matrix. Here, the players are to tilt their Game Cubes to the colored side that they believe had the most number of colored pixels, where the LED Matrix either shows a full display of green pixels, indicating the player was correct, or a full display of red pixels, indicating the player was wrong.

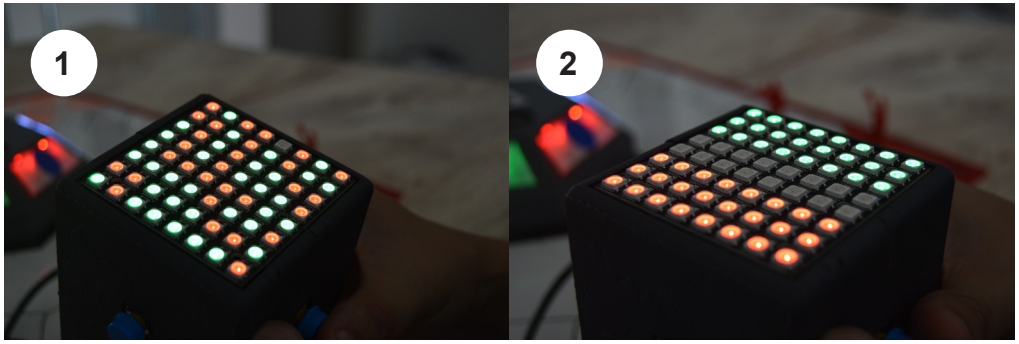


Figure 8.28: *The mini-game called Guess the Dots.*

The third and final game is *Quick Snake* (Figure 8.29), in which players navigate a red dot towards different blue dots for points; (1) When initiated shows a red and blue dot on the LED Matrix. (2) The player controls the red dot by tilting the Game Cube and gains a point when collecting a blue dot by having the red dot touch it. After each blue dot is collected, a new one will be displayed on the LED Matrix in a random location. The first player to collect a total number of ten points wins the game, where the LED Matrix will flash green.

Figure 8.29: *The mini-game called Quick Snake.*

8.3.4 Trivia Brawl

As with the walkthrough of Ludo Brawl, the following subsection describes the gameplay of Trivia Brawl and provides in-game examples for explanation purposes. (Figure 8.30); (1) When Trivia Brawl is selected through the game hub the game will initiate. (2) Then all lights will turn green to indicate the game has been selected and ready to play. (3) In addition, the display will showcase six different categories of questions. These categories are displayed in different colors corresponding to the six button lights on the game hub. (4) A player initiates game play by throwing a dice and going the corresponding number of times, with the player deciding which direction to go, as long as they follow the drawn lines. (5) Whenever a player lands on a colored field on the Game Board, they must press the correlating color on the hub, which each represents a category of questions. In this case, the player landed on a blue field, and subsequently must press the blue button for a question within the music category. (6) As a player pushes the colored button, a question will be displayed on the screen. On the screen will also be displayed ‘Hint’ and ‘Answer’ in green and red respectively. (7) If the player presses the green button representing a hint, (8) they will be taken to a new screen showcasing a hint for the question. (9) If they choose to use a hint, they will however have to give up a pixel in compensation, and thus only have the opportunity to gain 1 pixel from the question. (10) Once the questions have been answered, the player can press the red button, (11) to display the answer on the screen. (12) If the player was able to answer the question correctly, they receive a pixel they can acquire from the Hub. The game is complete when a player is able to correctly answer one question of every category in the game, where the winning player is allowed to gain the number of pixels that have been discarded throughout the game.

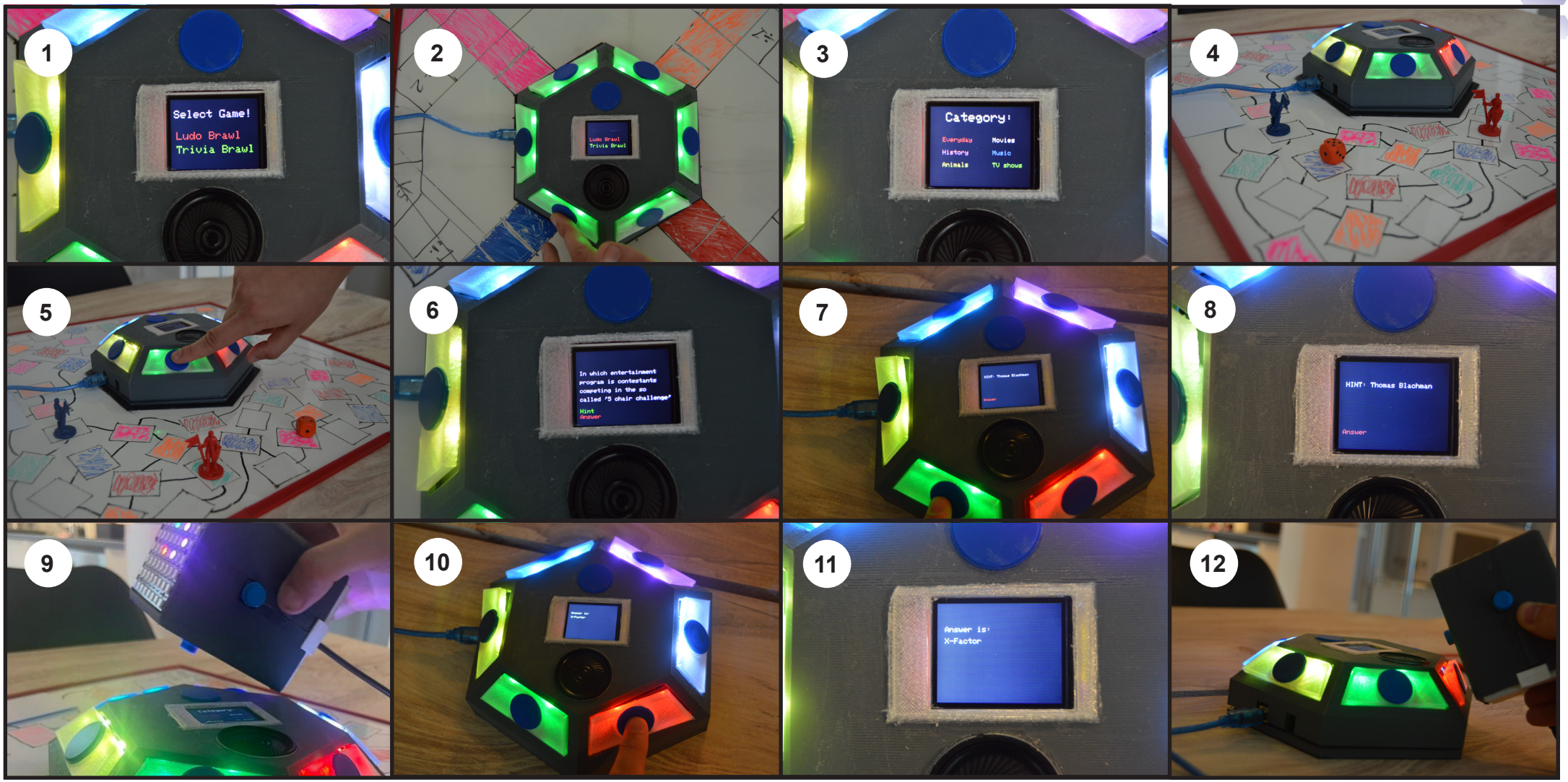
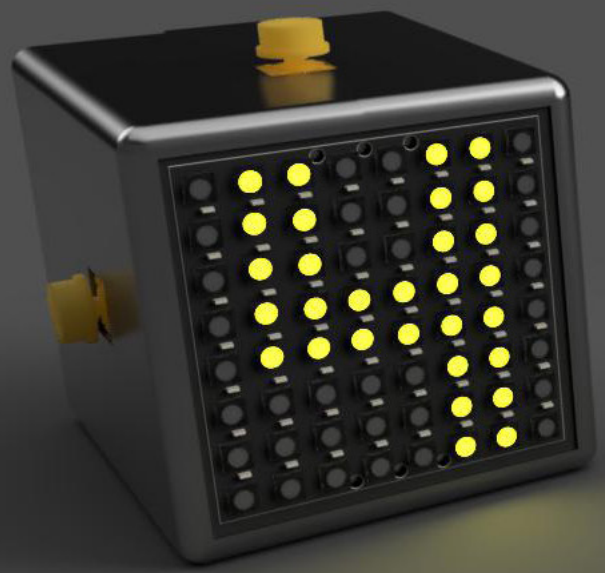


Figure 8.30: *Step-by-step guide of Trivia Brawl.*



Part 4: Findings & Discussion

Part 4 describes and discusses the findings of our Master thesis project and encompasses four chapters: 9. Evaluating Hybrida, 10. Discussion, and 11. Conclusion. In this part, we assess our high-fidelity prototype HYBRIDA with four participants to investigate the implementation of non-fungible tokens in a hybrid board game. We use our findings to reflect upon existing studies within the research area and to answer the two research questions of this study.

9. Evaluating HYBRIDA

Chapter 9 outlines the process of evaluating our high-fidelity prototype HYBRIDA. We attempted to conduct an evaluation in *natural settings involving users*, as this evaluation type allows practitioners to observe users interacting with a product in its intended surroundings [34]. Since essential interactions of playing board games derive from embodied processes and the social situation itself, we wanted to assess HYBRIDA under natural circumstances. However, the evaluation setting may resemble a "laboratory" with a social atmosphere due to our level of control and use of technical equipment. With this, the three succeeding sections provide an overview of the evaluation participants, setup, and procedure, while the two last sections describe the data analysis and findings.

9.1 Participants

We recruited four of our six workshop participants to evaluate HYBRIDA. Specifically, we retrieved IxD1 and IxD3 from the group of interaction designers and NFT2 and NFT3 from the NFT enthusiasts (Chapter 6). As the participants had agreed to participate in a second game session when asked at the workshop, the recruitment process was straightforward; we made a shared group chat with all six participants and provided a list of possible dates for the evaluation. Then, we choose the date when the most participants could partake. We decided to ask our previous participants to evaluate HYBRIDA as they were familiar with the focus of our study and existing design ideas, which gave us a chance to follow up on the ideas that were discussed during the workshops. In addition, as the participants could see their feedback being materialized through the prototype, they were indirectly encouraged towards a deeper engagement in the evaluation.

9.2 Conducting the Evaluation

Common methods for evaluating in natural settings include observations, interviews, and focus groups, where the facilitators have little or no control [34]. As such, we decided to combine observations with a focus group interview, where the interview questions were semi-structured. With this combination of evaluation methods we seeked to examine the interactions with HYBRIDA and the social process that occurs between the participants. In addition, the subsequent focus group interview would enable us to probe into interesting observations while also asking the participants predefined questions to cover specific topics. Moreover, we chose to conduct the evaluation as one shared session, with interaction designers and NFT enthusiasts playing together, instead of two separate. As we assume, the participants may develop new opinions and thoughts when communicating with other expert groups in a social context. The method of focus groups is also known to encourage a supportive and safe environment, allowing participants to explore their creativity based on the input of others [34].

In advance of the evaluation, we assigned each group member a role; one facilitator and two observers. The facilitator was responsible for explaining the functionality of HYBRIDA and the gameplay of the two game modes, Ludo and Trivia. This role was also tasked with questioning the participants and guiding the discussion during the following focus group interviews, ensuring that no one's opinion was left unheard. The two observers were accountable for inspecting the participants while playing and taking notes about any significant events. We used these notes to explore topics that were not a part of the pre-established interview guide (Appendix E).

9.2.1 Setup and Roles

Aiming to assess HYBRIDA under natural settings, we held the evaluation in the living room of one group member, as this is commonplace for playing board games. Two and two participants were seated at each side of the dinner table with the Game Hub and Game Board placed in the middle (Figure 9.1). The facilitator sat together with the participants while the two remaining observers sat in the background to avoid being obtrusive or hinder embodied and social interactions. We captured the evaluation with a video camera and audio recorder, using a similar setup as during the workshop (Section 6.2). Although video recordings can be intrusive and impact the behavior of the participants, we deemed it acceptable as the camera was placed in the background.

9.2.2 Procedure

Before starting to play, we divided the four participants into two teams; one with the interaction designers and one with the NFT enthusiasts. We grouped these participants together as they were familiars, making it easier to collaborate as they would speak more freely. The participants were intentionally supposed to play by themselves, but due to technical difficulties, we only managed to build two Game Cubes. Each team received a Game Cube, which their interactions with HYBRIDA focused around.

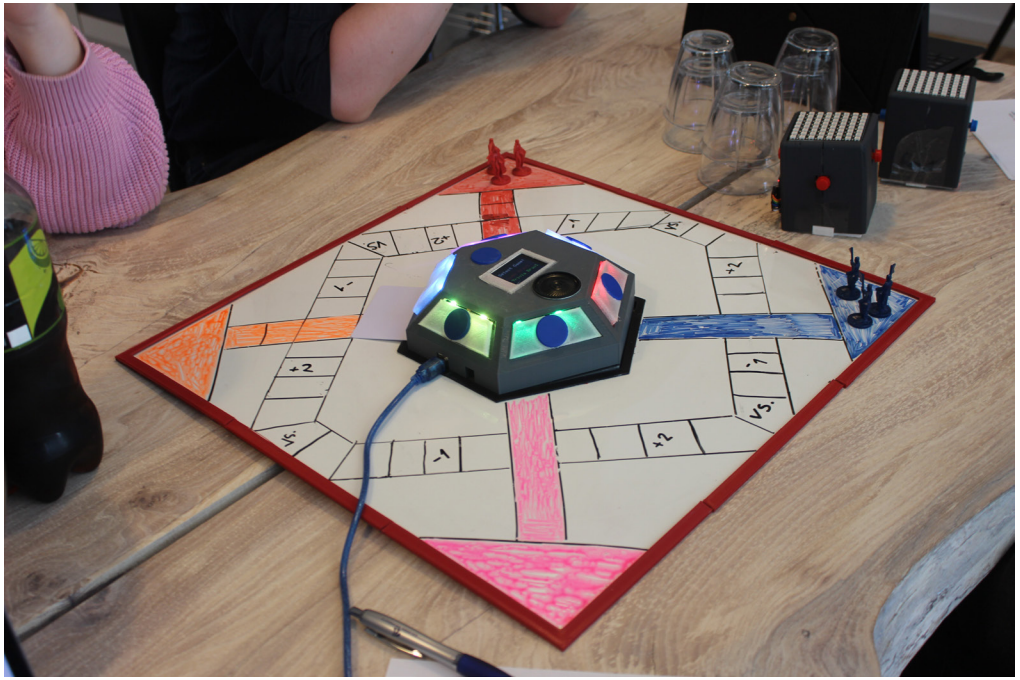


Figure 9.1: *The setup of HYBRIDA during the evaluation.*

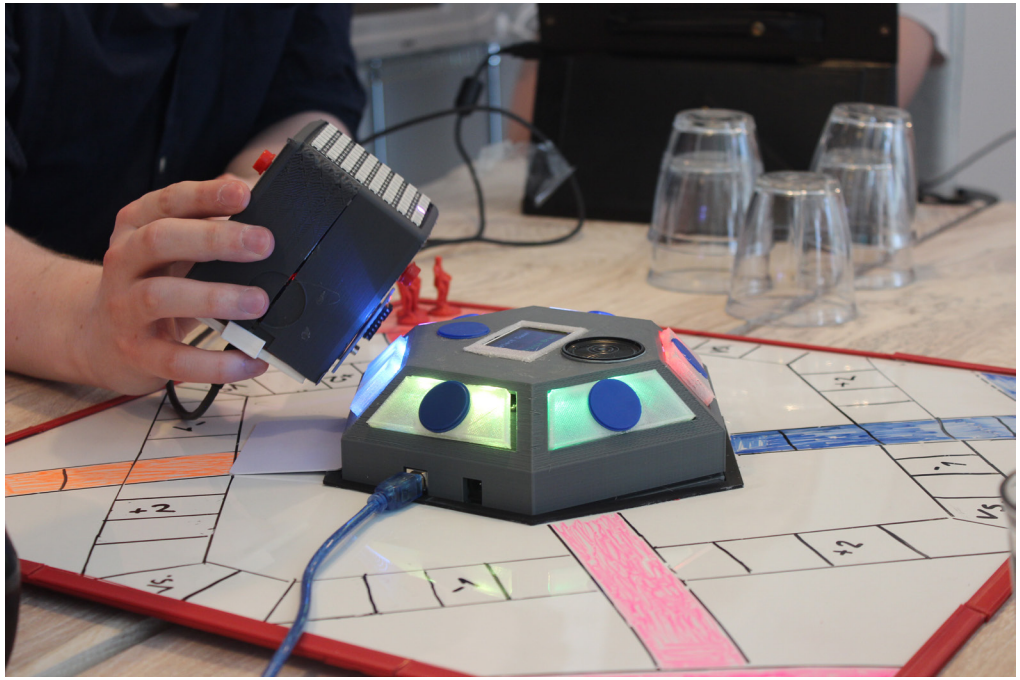


Figure 9.2: *The participants testing out the interactions with the Game Hub using the Game Cube and its associated buttons.*

After receiving the Game Cube, the facilitator explained how HYBRIDA functioned and how the participants should interact with its components. Subsequently, we asked the participants to try interacting with the Game Hub and Game Cube, ensuring that everyone understood how to use the HYBRIDA components. Specifically, they received the task of picking three colored pixels from the Game Hub and placing these on the Game Cube using its accelerometer (Figure 9.2). As the participants had grasped the interactions, the facilitator continued explaining the new gameplay of Ludo Brawl, including its rules and mini-games. Ludo Brawl was the first game mode in HYBRIDA that we evaluated.

While the participants played Ludo Brawl, the two observers examined their interactions and verbal expressions, which they noted accordingly. As the facilitator sat together with the participants, he was always available to answer potential questions or clarify game features. When one team won Ludo Brawl, we continued to the next game of Trivia Brawl, which was played for thirty minutes where the facilitator decided to end the game, to ensure the evaluation would not extend over the planned time frame. The evaluation ended with a focus group interview which was conducted by the facilitator asking pre-written and open-ended questions (Appendix E), which the participants then discussed openly between each other.

9.2.3 Technical Issues

In advance of and during the evaluation, we experienced a few technical issues with the Game Hub and Cube. In preparations for the evaluation, we calibrated the ADXL335 accelerometer implemented inside the Game Cube. However, when connecting it to the 9C battery instead of the USB cable, as we usually did, it became less predictable.As a result,

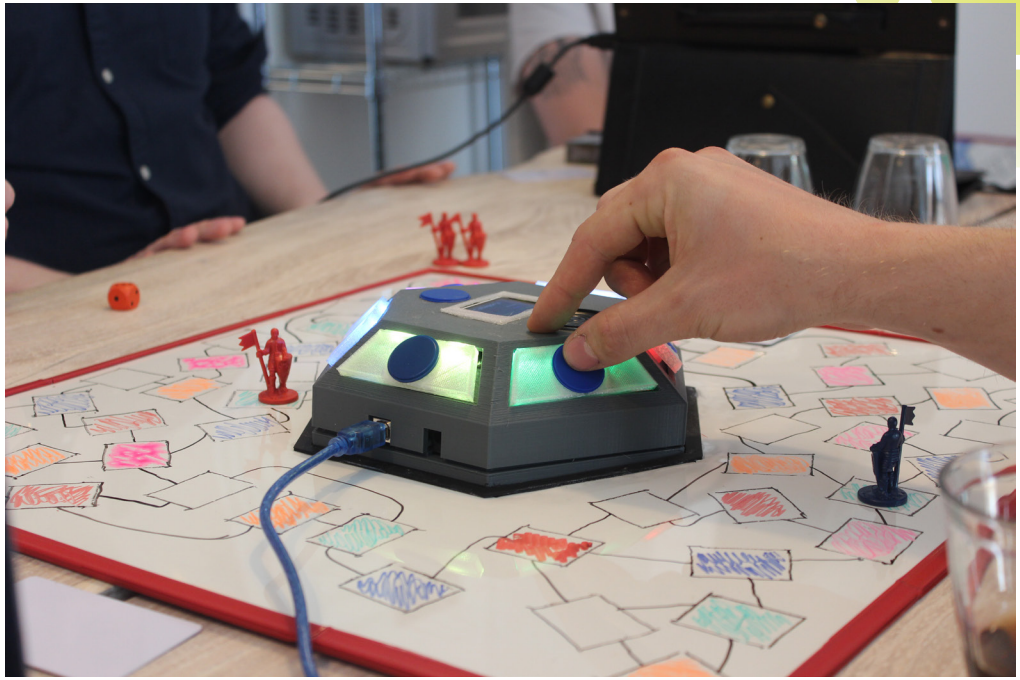


Figure 9.3: *The participants playing Trivia Brawl.*

the participants had a tougher time interacting with the Game Cube than intended, yet it was still manageable. Furthermore, due to time restrictions and technical complications during construction, the speaker was not fully implemented. Based on this, the Game Hub did not provide audio feedback regarding the participants' actions.

9.3 Data Analysis

Our data consisted of observations, notes made during the evaluation, and a transcription of the video recording. We organized and analyzed the data by performing a qualitative content analysis [23], in the same manner as with the workshop data (Section 6.3). As the evaluation was conducted as a single session, we decided that one group

member would transcribe the recordings while another would code the transcriptions afterward. We defined a few content categories based on the purpose of the evaluation beforehand, such as the *ownership* and *transience*, while the responsible group member could provide additional codes as needed. From the qualitative content analysis, four main categories and 13 sub-categories emerged, as presented in Table 9.3.

9.4 Findings

In the following section, we explain the findings from evaluating HYBRIDA, presented in Table 9.3, and exemplify them with quotes from the participants. The individual participants are referenced according to their previously labeled names from Chapter 6. Based on the themes from our data analysis, we divide the evaluation findings into three separate subsections concerning: 1) views on HYBRIDA as a hybrid board game, 2) NFTs as a design material in HYBRIDA, and 3) the physical construction of HYBRIDA. In each section, we provide a short description of the main findings before going in-depth with specific observations, quotes, and suggestions made by the participants.

9.4.1 Perceptions of Hybrid Play

We identified four topics concerning the participants' experiences and perceptions of the hybrid play in HYBRIDA. The first two topics revolve around the ways in which the Game Cube interactions and associated mini-games provided enjoyable and fun experiences. The third topic deals with the balance between tangible and digital elements in HYBRIDA, while the fourth relates to the benefits of customization.

Category	Subcategory	References
Game Hub	Constructive Criticism	8
	Positive Feedback	7
	Interactions	2
	Customizable	
Game Cube	Constructive Criticism	8
	Positive Feedback	3
	Interaction	6
	Pixel NFT	13
	Mini-Games	6
Hybrid Board Games	General	5
NFTs	Ownership	14
	Transient	6
	Community	3

Table 9.3: *The count of references found from coding the transcription of the evaluation*

Interaction of acquiring colored pixels

The observations and comments about the Game Cube interactions suggest that interactive game pieces, as defined by Mora et al. [29], provide fun and meaningful game experiences. Although the bulky design of the Cube provided awkward interactions at times, three out of four participants still enjoyed interacting with it. To exemplify, IxD 3 commented about the interaction of acquiring pixels: "*I really liked the way you had to do it, since if you got 2 points [color pixels], then you have to go and collect them yourself [from the Hub]"*. The participant continued describing the Game Hub as a sort of bank where players make transactions of acquiring or depositing colored pixels. Meanwhile, NFT 1 would rather have the interaction completely automated, finding it cumbersome to physically move the Game Cube. The participants also discussed the interaction of positioning pixel dots on their LED Matrix, where NFT 2 mentioned liking the mixture of rotational interactions and button use. NFT 1 agreed while also addressing the issue of fine-tuning a pixel placement, stating: *"Yeah I think so as well, it was fun turning it [Game Cube] around. However, if I really would like to fine-tune the placement of the pixel, then it would probably be easier using the buttons"*. IxD 1 and IxD 3 added that there was no way of changing the positions of the pixel dots after locking them in a specific spot, which could lead to frustrations. Based on this, NFT 3 suggested *"... If you had a form of a screen [Touch] where you could just touch one of the pixels you want to move and place it another place in the same way"*.

Benefit of Playful Mini-Games

Regarding the mini-games, the participants' comments indicate that implementing digital elements of this kind provides fun and immersive segments in HYBRIDA. However, the mini-games also lessened the social interactions between the participants, as they felt confined to engage with the individual Game Cube. To elaborate, all participants found the mini-games fun and engaging, as they provided an additional layer of playfulness to an otherwise simple version of the original Ludo. For example, NFT2 exclaimed: *"I really like the Versus mode [mini-games]",* followed by IxD3 saying: *"It was fun with those mini-games. It gave the experience something extra"*. However, NFT1 also addressed an issue concerning the social interaction of the mini-games, explaining not feeling as if they were directly playing against each other but rather, for a high score. IxD3 agreed with this comment and replied with: *"It would probably be better if you could see the opponent on the screen, or something like that, to give the feeling of playing with each other"*. IxD3 then followed up on this statement and suggested a way for the players collaboratively engage with the mini-games: *"So if we are talking about a way to play together, if we each had one [Game Cube], then by placing them together the display [LED Matrix] would get bigger and we could play with or against each other"*, which was an idea the remaining participants also liked. Furthermore, NFT2 mentioned using the tactile buttons for special moves during the mini-games, wanting more complex actions within the games.

Balance Between Physical and Digital

As a general discussion surrounding HBGs arose, the participants provided various views on what elements in analog board games are beneficial to digitize and to what degree. While agreeing that digitizing instructions and game pieces can optimize game experiences, they also expressed that this could reduce meaningful tangible interactions. To exemplify, NFT 2 mentioned that he found analog board games to benefit from digital hosts or game masters: *"Depending on what type of board game it is, then it [digital element] can really enhance the experience. There are board games where you have a host on the TV, as an example"*. Digital

technology can also organize complex board games that consist of many tokens, cards, and rules, as NFT3 explained. This participant often used a mobile application while playing to track game states or even replace actions, like card drawing. IxD3 found the combination of tangible and digital elements in HBGs interesting, but expressed that there should be a balance: "*... I like board games more than video games, because I like the physical aspect"*. In the end of the discussion, the participants concluded that digital implementations can be beneficial in the right context of games.

Customization of HYBRIDA Game Boards

The comments concerning the ability to customize the HYBRIDA Game Boards proposed that giving too much freedom can be overwhelming and hinder play. The participants expressed the importance of having limitations or guidelines to manage the degree of customization, ensuring a properly balanced game setup. For example, IxD3 commented: *"I think I would find it quite unmanageable to set it up [HYBRIDA] if I could just change everything, without any guidelines […] So I think it can be too much customization in that sense".* Thereafter, NFT3 suggested creating modular game board pieces unique for each player owning one: *"Every player could also own a custom piece of the Board Game, which could be attached to other players' pieces, creating a new setup most times''.* This suggestion would make HYBRIDA customizable yet pre-defined and constrained by the individual board game pieces. Additionally, NFT2 proposed incorporating online features to the Game Hub, allowing players to download additional game modes.

9.4.2 NFTs as Design Material

We classified three topics regarding the use of NFT characteristics as interaction design material, including perceptions on utilizing transience, ownership, and community-driven interactions.

Utilizing Transience in Hybrid Board Games

In regards to the features of transience in HYBRIDA, observations and comments imply that utilizing transience as design material is valuable if incorporated in the right context. After transferring from Ludo Brawl to Trivia Brawl during the evaluation, we observed that participants, at first, were hesitant to deposit their colored dots for a better chance of answering a Trivia question correctly. However, later in the game, the participants realized that the feature gave them a better chance of winning and began using it. To exemplify, IxD3 said: *"It was fun transferring over to the other game [Trivia Brawl] because in Ludo Brawl we could not really use our colors [colored dots] for anything. In Trivia Brawl, they suddenly had a value in the game",* with other participants firmly agreeing. IxD1 added: *"Even when it [Game Hub] got turned off and then on again, our NFT picture was still there"*. While all participants enjoyed said transient feature, NFT2 and NFT3 also addressed the issue of abusing it to win. They explained that players could keep playing one specific game to gain a profound amount of colored pixels, providing advantages in another game session: *"I think you would need some kind of moderation, because people would abuse it"*, as NFT3 mentioned. NFT2 then added: *"Yes, that is where you should set limits for how much should be controlled [By the game rules] and how much the community should control, because we all know that if there are no rules at all, then it is the wild west, that is generally how the internet works"*.

After discussing the transient features in HYBRIDA, the participants discussed other contexts and applications wherein they could use their pixel dot NFTs. Their suggestions included digital aesthetics, like a mobile phone background or a profile picture, and other digital games. In addition, NFT2 and NFT3 mentioned that to truly experience the transient nature of NFTs, additional sessions over a longer period of time could have been beneficial.

Perception of Ownership and what it entails

The participants' comments indicate that an immediate sense of ownership towards the colored dot NFT may not necessarily appear when starting with an empty LED Matrix (or NFT). Instead, the feeling of ownership evolves over time as the player acquires pixels to create something meaningful. When we asked the participants about their relationship towards their NFT after having played both HYBRIDA game modes, their opinions were mostly indifferent. The participants explained that if they played with their NFT over multiple game sessions of HYBRIDA, they would most likely have developed an emotional bond. For example, as NFT3 explained: *"Since the whole idea behind these NFTs and gaining dots [Colored Dots] to create some personal figure or picture, and end up having a lot of dots and an almost complete picture, then knowing that there is a higher chance for me to lose that creation [NFT] would make me not wanting to play anymore".* Based on this concern, the participants began discussing the topic of "finishing" an NFT, which they referred to as feeling satisfied and done with the image of colored dots on the LED Matrix. For example, IxD3 expressed: *"There would be a time where id think the picture [NFT] is done, even if there is still room for more colors [Colored Dots], as an example a simple smiley, so when I have made my smiley but I am still winning additional pixels, then it might end up ruining my picture"*. The other participants agreed with this statement and suggested having the possibility to archive an NFT image, either after or during time of play. This feature would also give players an opportunity to create a personal gallery of NFTs, encouraging sharing of images and sociability within the NFT communities.

From the discussion of NFT archives, we asked about other ways of storing NFTs, such as using the Game Cube as an interior in their homes. All the participants liked the idea of having an NFT decoration but mentioned that its design was of great importance, as IxD1 commented: *"If it didn't feel too weird having it on display, like, that other people know what it is, then maybe. [...] It also really depends on how it looks"* and NFT3 adding: *"Maybe the design could be like that of a Google Nest, where it is a bit tilted with a display and showcases your NFT, and then the more NFTs you create, it kind of zooms out and shows them all"*. Another suggestion proposed by NFT3 involved creating high-resolution pictures by putting segmented NFTs together, as he explained: *"When you have won multiple pixels over, like 100.000 games, the overall picture gets bigger and do not look so blockish, but looks like a real figure"*, which the remaining participants also felt appealing. Lastly, NFT3 mentioned having a hub at home that showcases the NFTs, while the Game Cube could be placed on top of it to charge and deposit any new NFTs gained.

Sharing through online community

All the participants liked the idea of community-driven interactions in creating social play, despite not explicitly integrating this NFT characteristic into HYBRIDA. While the participants mentioned several suggestions for community platforms, such as NFT image tournaments and exhibitions, they also addressed that not all players may want to engage. For instance, NFT3 explained what type of community-driven interactions he would prefer, stating: *"Some sort of community and community events,*

where you can share your things [NFTs]", with NFT2 adding: *"If there are more creative features online, then I think it would give more value to the individual user, as you also get some kind of acknowledgment from the community"*. Other proposals made during the discussion about NFTs and their associated communities concerned online games, creative picture tournaments, and alternative ways of showcasing NFTs. However, IxD3 expressed that she preferred interacting with friends and familiars, saying: *"I think for me, there should not be too many things to do, as that would not be something for me. Maybe a feature of being able to play remotely with friends would be interesting though"*. Later in the discussion, the participant mentioned that a reward for participating in community events would motivate her: *"It would be fun if winning an Aalborg Championship in Ludo Brawl would reward you with a special pixel that could, for example, be gold. That would be cool, like a trophy".* The other interaction designers agreed with this idea, suggesting special pixels like blinking between colors or moving around on their own.

9.4.3 Physical Design and Construction

We found three topics relating to the participants' perceptions of the physical construction of HYBRIDA. These included the placement of external components, the inconvenient Game Cube size, and suggestive ideas for said construction issues.

Placement of External Components

Observations and comments from the participants suggest that HYBRIDA undermined the availability aspects of providing a visible and accessible game area. As we observed, the participants had difficulties interacting with the Hub-buttons on the opposite side of their seated positions. For example, they got up from the chair to properly reach the opposing buttons for acquiring colored dots. The participants also asked the other team for help in Trivia Brawl, as they could not receive questions, answers, or hints without stretching over the Game Hub. This issue was confirmed during the focus group interview, where NFT3 commented: *"If you are playing with a thing [Game Hub] at the size of this, then it can be difficult to press the buttons on the opposite side, where you might have to ask other players to press it or stand up to do it. It would be nice if all buttons were accessible to all players"*. The other participants also agreed with this statement, whereafter NFT2 suggested using a modular approach for the Game Hub as he stated: *"You could even separate the buttons from the Hub and just connect them if needed for other games"*.

While playing Trivia Brawl, the participants also had problems perceiving and reading the text on the LCD TFT display due to its placement and font size. IxD1, who viewed the screen from an upside-down position, stated: *"It is a little hard to read from the opposite side"*, with IxD 3 validating it. As such, NFT2 proposed other placements of the LCD TFT display: *"Instead of having the display on top, maybe place a number of them around the positions of the buttons and put the buttons on top, or a screen that turns around"*, with NFT 3 adding: *"Or like a tree on top, with displays pointing in four directions''*. As these two suggestions would require an abundance of screens, the participants continued discussing more simple solutions like larger, rotating displays or audio feedback.

The Game Cube Size

As observations indicated, the participants were impressed by the LED Matrix on top of the Game Cube, liking how they used it for various features during time of play. However, as they pointed out, incorporating an LED Matrix was the detrimental factor for the larger size of the Game Cube. In the focus group, the participants discussed the inconvenient Game Cube size with NFT2 saying: *"If it was one-third of its current size,*

then you could also use it [Game Cube] as a token [Player Token] on the game board". The remaining participants also expressed that its bulky size was slightly cumbersome. Based on this, IxD3 suggested having Player Tokens as attachments to the Game Cube, enabling players to disengage and move them around the Game Board while still being wireless connected. Furthermore, we observed the participants often using two hands to manage the Game Cube, which led to a few awkward interactions. For example, when having to interact with the RFID tags on the Hub-buttons as NFT3 mentioned: *"The problem was that it was difficult to see where the scanner [RFID-scanner] was landing"*. NFT2 made a comparison of this issue to the bus-card scanners in the Danish buses, where the large size of the scanner makes it nearly impossible to miss them. Subsequently, IxD1 proposed a new placement of the RFID-scanner: *"I do not think it would have been a bad idea to put it [RFID-reader] at the bottom [of the Game Cube]"*. Other suggestions included the use of visual, tactile, or audio feedback, indicating that the RFID-scanner had registered a token.

10. Discussion

Chapter 10 reflects upon the conduct of our Master thesis project and discusses the study's contribution in relation to previous work within the research area. Herein, we also consider study limitations concerning participant biases, construction difficulties, and fulfillment of requirements.

10.1 Reflecting on our findings

To understand our contribution to the field, we compare the findings of this project with the results of previous research (Chapter 2). The subjects that we touch upon include interactive game tokens, social interactions, and integration of NFT technology.

10.1.1 Interactive Tangible Game Pieces

Mora et al. [29] propose the idea of designing *interactive game pieces*, referring to tangible game pieces enhanced by the features of digital components. The authors explain that added interactivity enables physical game pieces to inherit the two common *roles of representation* and *control*, otherwise provided by different tokens. Representation concerns the *function* game pieces have as a visual representation in board games, which comprise intangible *representation* like dynamic information on a digital display, and tangible representation such as physical shape or color of a token. The role of control is connected to *actions* that force the game in a forward direction, like rolling dice or drawing cards. By integrating interactive game pieces rather than fully digitizing them, Mora et al. [29] suggest that the physical affordances are more likely to stay intact [29].

The design direction introduced by Mora et al. [29] resembles our focus while creating HYBRIDA, which led us to the interactive Game Cube that each player is in control of. We would argue that the Game Cube is designed and used as an *interactive game piece*, as it acts as the main point of interaction throughout the play with HYBRIDA. We also believe that the Game Cube inherits the roles of both control and representation, including *intangible* and *tangible* representation. The Game Cube encompasses *control* as the LED Matrix represents the state of the players' NFTs, and Cube software pushes this state forward when players acquire colored dots or compete in mini-games. Concerning the role of *representation*, the Game Cube introduces tangible representation through its physical shape, material, and size. The *intangible* representation occurs through the dynamic information or LEDs displayed on the LED Matrix. The different types of *roles* or activities integrated into the Game Cube had an overall positive impression on the participants; they liked the tangible experiences of moving, holding, and using the Cube with the Game Hub, meanwhile enjoying the digital elements of playing mini-games and creating a personal NFT. However, it became apparent that using the Game Cube as a movable player token would become more of an inconvenience than a positive experience due to its larger size. From this, we learn that when designing interactive game pieces, the implementation of digital components may change the tangibility and physical affordances of the token itself. As such, we believe it could be interesting to fully transform the Game Cube into an interactive game piece, making it more appropriate as a player token.

Mora et al. [29] also brings up the subject of a first and second *interaction loop*. The first interaction loop appears in most analog board games as it involves moving or manipulating tangible game pieces. The second interaction loop occurs when the technology used with the interactive

game pieces senses the manipulation from the first interaction loop and acts accordingly. Discussing these loops in relation to HYBRIDA, the players encounter the first interaction loop when moving their player tokens around the Game Board in a turn-based structure. The interaction of moving the Game Cube toward the Hub to achieve a colored dot is also an example. The second interaction loop starts when the Game Cube identifies an RFID tag on the Game Hub and initiates the action of placing a colored dot on the LED Matrix, also called a *token-token* event according to [29]. The second interaction loop is also present when players initiate a mini-game. As we learned, awareness of these interaction loops makes it easier to design gameplay, as they provide an understanding of each game round and the overall game flow. We would also propose a third interaction loop that is present in the background of the overall HBG experience. The players experience the third loop when placing a colored dot in their NFT tilting the Game Cube. This interaction has no direct impact on the overall game state itself, meaning that the next player may begin their turn while this interaction loop is ongoing. Based on this, the third loop keeps players engaged with an interactive game piece related to the game but has no direct impact on the game itself.

10.1.2 Social Play

Xu et al. [48] suggested five categories of social interactions that are of importance when designing HBG elements; 1) *Chores*; 2) *Reflection on gameplay*; 3) *Strategie*; 4) *Out-of-game*; and 5) *Game itself*. During the evaluation of HYBRIDA, we observed a few of these categories while the participants interacted with each other and the setup itself. For example, when playing Trivia Brawl, the participants with the TFT LCD display pointed toward them often took it upon themselves to do the chore of reading questions for the remaining participants. While Trivia Brawl promotes certain passive interactions, as pointed out by a participant, the chore of reading gave all participants a common social ground. This type of *chore* could have been automated by the Game Hub presenting the questions through a speaker, reducing the social interactions. As the participants played HYBRIDA, teammates would often discuss which player token to move during their turn, reflecting on the *gameplay* and the *strategy*. However, these social interactions were mostly products of teaming up the participants, driving them to communicate with each other before making an agreed action. *Out-of-game* socializing was not as apparent as in the other categories. However, we believe that the setting of playing in an evaluation limited this type of social interactions from emerging. *The game itself* did not have specific features designed to enhance social interactions. Even so, the mini-games often sparked social intercourse between all participants, providing quick interactive experiences they could briefly reflect on afterwards.

HYBRIDA is a *turn-based* board game, meaning that players take turns to do actions. This type of game structure provides downtime for the players who have already completed their turn, giving room for social intercourse. As we observed during the evaluation, the flow of HYBRIDA encouraged the participants to socialize between turns; discussing topics like the placement of colored dots, the player's last move, the strategy of the opponents, or regular "chit-chat." Xu et al. [48] mention said phenomena and describe that a turn-based structure also creates a shared center of attention, where the focus switches between whoever turn it is. As such, the game structure can ensure that socially dominating individuals do not fill the entire room, giving more space to shy players. To exemplify, the turn-based flow of HYBRIDA promoted social intercourse when one team spent extra time considering what to answer in Trivia Brawl, as the opposing players jokingly suggested that they should en-

force a timer to restrict discussion time. These comments led to a friendly debate amongst all participants.

Even though Nummenmaa and Kankainen [31] encourage designers to create features solely focusing on enhancing social interactions, like *communication through the game* or *advanced bluffing*, we ultimately decided to avoid this. We learned through our technology probes that forcing players into a social activity, such as the trading phase during NFTs Against Reality, does not necessarily ensure natural social intercourse. Therefore, we focused on giving room for players to socialize between or under actions, like Xu et al. [48] propose. Overall we find it complicated to design for social intercourse or play, as we believe it depends on the game type, the people playing, and the setting in which the play should occur.

10.1.3 NFTs in HBGs

Integrating NFT characteristics into HBGs has in itself been a challenge, especially due to NFT technology being built and designed with digital platforms in mind. However, as Min et. al. [26] suggests that many of the characteristics of NFTs can be applied to that of digital games in a meaningful way, as long as it is properly integrated, indicating it should be possible to integrate in other types of games, such as HBGs. The characteristics that Min et. al. [26] presents are *asset ownership, asset reusability, system transparency* and *user-generated content*, which we would argue we have implemented in a valid way to HYBRIDA, excluding *system transparency*. The *asset ownership* characteristic is present in the design choice of players creating their own NFT during time play, and are in fact the only ones owning it. *Asset reusability*, or transient as we have named it, is present when players of HYBRIDA are able to take their built NFT from one game type to another, using the NFT for different purposes depending on the game itself. *User-generated content* is also present in much the same way, as players upgrade their own NFTs during time of play. This could be further expanded beyond that of the NFT itself, by implementing an online feature to HYBRIDA where players can create their own game types for others to download and play.

As Scholten et al. [37] and Serada [39] have investigated the detriments of crypto games, notably that of gambling, an agreement between the group members came that we wanted to avoid design choices that would include gambling principles or promote the negative aspects of the play-to-earn philosophy. Instead, we wanted the value of the NFTs to be rooted in personal attachment and be seen as a valuable game resource, rather than that of market value. This also became apparent from our workshops, as mostly all participants were dismissive of incorporating trading aspects close to that of crypto markets, into HBGs, as it being more disruptive than enjoyable. We believe we have achieved in doing so, by having players build their own NFT from scratch, giving them sentiment to keep it rather than selling it, as it can be considered that of a trophy or a visualization of their progress playing HYBRIDA. However, this would need an extended study over multiple sessions with participants keeping their NFT between sessions, to fully be explored.

Lastly, due to the nature of NFTs, and in extension crypto, being a complex subject to most individuals, resulted in questions from the IxD workshop group surrounding, *what, how* and *why* NFTs should be integrated into HBGs. From this we learned that if designing a HBG with NFT technology as a feature for a commercial product, then the feature itself could be intimidating for some individuals, and therefore the overall presentation and explanation of such feature should be considered for those individuals.

10.2 Limitations

In the following section, we present limitations that we experienced during the making of this project. These limitations are related to potential participant biases, prototype construction, and requirements.

10.2.1 Participants and Evaluation

For the evaluation of HYBRIDA, we decided to recruit some of the participants attending the workshop, specifically two NFT enthusiasts and two interaction designers. We chose to use participants from the workshop as we believed it would benefit the evaluation of HYBRIDA. Explicitly we considered that because the participants knew the initial idea and scope of our project from the workshop, they would be able to reflect on the improvements and comment on whether the changes made based on their feedback was properly integrated. Looking back, this could also have resulted in the participants becoming biased when attending the evaluation, as they might have a negative reaction if they had suggested a feature for the final prototype during the workshops, and then experienced during the evaluation that the suggestion had not been implemented. However, we dont believe this was the case during our evaluation, as no obvious responses by participants indicated such, but nonetheless it was something we reflected on after the evaluation. Furthermore, by not having new participants for the evaluation, we may have missed some data surrounding first-impressions, in which our participants already had an idea of what direction our project was going, and therefore also an idea of how the final prototype could end up. At the evaluation, we paired the four participants into two groups, since we had only two Game Cubes available. This could have led to some different data compared to them individually having a Game Cube each, as they would each have full control over what they wanted to make as an NFT, as well as which actions to take during time of play.

10.2.2 Prototype Construction

When deciding which technical components should be incorporated into HYBRIDA, we sometimes had to limit ourselves to not overextend our budget. As an example, when choosing the display for the Game Hub, which could have benefitted from being larger. Furthermore, as we had a predefined date for the evaluation to take place, we were also under pressure of building the prototype HYBRIDA in time. This led to only two Game Cubes being fully constructed in time, while also additional features, such as audio feedback, got discarded during construction. Lastly, when constructing the 3D printed shells for the pieces for HYBRIDA, additional iterations would have been preferable, as it became apparent during evaluation that some minor changes could have benefitted the overall experience of interacting with HYBRIDA.

10.2.3 Requirements

During the development of requirements for the final prototype version of HYBRIDA, we narrowed the selection down to a total of 22 requirements; ten functional, six non-functional, and six NFT-related requirements. However, a few of these requirements were not fulfilled or only partly fulfilled due to either prototype limitations or because they were deemed unnecessary during the development of HYBRIDA. The following table (Table 9.1), showcases which requirements were fulfilled, which were partly fulfilled, and and what requirements were not fulfilled.

ID	Requirement Description	Prioritization	Degree of achievement
F.1	Support interaction between player and hybrid board game	Must have	Fulfilled
F.2	Provide meaningful feedback to the players about the state of the game	Must have	Fulfilled
F.3	Utilize digital aesthetics to enrich the gameplay	Must have	Fulfilled
F.4	Allow players to continue playing if technology fails	Should have	Not Fulfilled
F.6	Automation of cognitive-demanding tasks	Should have	Fulfilled
F.7	Automatic and continuous tracking of user progression	Should have	Fulfilled
F.8	Automatic and continuous tracking of game state	Should have	Not Fulfilled
F.9	Implement interactive player-versus-player challenges	Should have	Fulfilled
F.10	Enable players to customize the board game	Should have	Fulfilled
F.11	Include dynamic levels of difficulty to open a broader range of accessibility	Could have	Partly Fulfilled
NF.1	Provide meaningful digital implementation to ensure tangibility	Must have	Fulfilled
NF.2	Utilize tangible interaction to enrich game experiences	Must have	Fulfilled
NF.3	Enable face-to-face and gestural social interaction	Must have	Fulfilled
NF.4	Provide an enjoyable level of automation	Should have	Fulfilled
NF.5	Hide confusing and non-essential electronic components	Should have	Partly Fulfilled
NF.6	Game area visibility	Should have	Partly Fulfilled
NFT.1	Implement transient features	Must have	Fulfilled
NFT.2	Enable upgradability of NFT game components	Must have	Fulfilled
NFT.3	Evoke sense of ownership towards assets	Must have	Fulfilled
NFT.4	Avoid negative play-to-earn mechanics	Should have	Fulfilled
NFT.5	Shareability in community	Should have	Not Fulfilled
NFT.9	Presenting NFTs in both a physical and digital form	Could have	Partly Fulfilled

Table 10.1: *An overview of which requirements we fulfilled, partly fulfilled, and not fulfilled.*

A total of 14 requirements were fulfilled, four were partly fulfilled and four were not fulfilled. As we look back upon the project, HYBRIDA and the evaluation of it, then there are some requirements that we would have liked to have explored further, but due to time limitations were not possible during this project. Requirement NFT. 1, that of incorporating transience features, which we believe is fulfilled, would have been interesting to delve deeper into. If we were to utilize this NFT characteristic beyond that of the context of HBGs, could lead us to other contexts that would benefit the overall experience of HYBRIDA, such as a digital platform where the NFTs created by players during time of play could be used in other ways, such as showcasing, crypto games, events, etc., which would in turn lead to the requirement NFT. 5, being that of shareability in community, conceivably being fulfilled as well. Requirement NF.6, that of game area visibility, is perceived as fulfilled due to the game board itself always being visible to all players. However, as the evaluation revealed that some interactions, such as pressing a button on the Game Hub or acquiring pixel dots with the Game Cube, became difficult due to the physical design of the game pieces often obstructed the view of the players during these interactions. Therefore, we would suggest an additional non-functional requirement that relates to clear visibility during interactions or actions during play.

11. Conclusion

With the current growth of popularity in crypto games, companies and researchers have begun investigating the future of blockchain mechanisms within the game industry. While recent studies introduce the many possibilities of blockchain, especially regarding NFT technology, they also emphasize the limitations and negative motivation of the current game applications. Based on this concern, we wanted to understand what characterizes NFT technology and use these characteristics to design new hybrid board game experiences. We decided to focus on NFT implementation within HBG, attempting to bring NFT characteristics from the digital space they were designed for, and introducing them to the physical space. As such, we asked ourselves the following to research questions:

Q.1: *"What Non-Fungible Token characteristics can be utilized as design material to create interactions?"*

Q.2: "How can we design a Hybrid Board Game with meaningful incorporation of Non-Fungible Token characteristics?"

This project has explored using characteristics of non-fungible tokens as design material in hybrid board games by introducing the prototype HYBRIDA. Based on existing work on crypto games and play-to-earn mechanics, we established and defined five NFT characteristics that could act as design material: 1) *ownership*, obtaining possession over an in-game asset in the form of an NFT; 2) *transience*, utilizing the owned NFT across game platforms and contexts; 3) *upgradability*, customizing and adjusting owned NFT; 4) *trading*, selling or exchanging NFTs or other associated game resources based on the owners perceived value of them, and 5) *community-driven interactions*, creating social connectedness by allowing user to share their personal NFTs and associated news in an open forum. We implemented all five NFT characteristics in three distinct technology probes and explored how they acted as design material through a participatory workshop. Findings indicated that each characteristic served as design material, providing unique and engaging game experiences in their distinct ways. Even though the participants enjoyed trading game resources to perform better and the community-driven interactions that emerged from this, they especially found the characteristics of ownership, upgradability, and transience fun and engaging; being able to customize their personal NFT and playing with it across game platforms created commitment and immersion in the game.

By constructing the high fidelity prototype HYBRIDA, we investigated how to design a hybrid board game with meaningful incorporation of NFT characteristics. Specifically, HYBRIDA integrates four characteristics, including ownership, upgradeability, trading, and transience; Ownership was implemented by creating individual Game Cubes, with an associated NFT image on top, for each player to personally own and engage with during play of HYBRIDA. Upgradability was integrated by allowing players to customize and adjust their NFT image through various features of acquiring and losing colored dots in both HYBRIDA game modes. Trading was applied by enabling players to sell two colored dots for a better chance of answering correctly on a Trivia question, and subsequently, winning the game. Lastly, transience was included by enabling players to apply the Game Cube across Ludo- and Trivia Brawl without the NFT image changing. Findings from evaluating HYBRIDA suggested that the implementation of NFT characteristics provided engaging interactions,

feelings of immersion, and attachment to one's NFT despite a few limitations regarding game accessibility. They also proposed that the participants perceived the many opportunities NFT technology brings to the design of board game experiences.

Our study demonstrates how NFT characteristics can act as design material and how they can be integrated in developing a hybrid board game. In the process of designing HYBRIDA, we have explored various approaches for incorporating NFTs characteristics, in both a physical and digital sense, and learned about the many possibilities of this technology.

Part 5: Sources and Appendix

Part 5 contains the in-text and image references used throughout the report, including appendices.

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Appendix
Appendix A: Workshop Preparations

21 Questions for preparing a workshop - The Skeleton Checklist

Source: *Chambers, P. (2002) Participatory Workshops: A Sourcebook of 21 Sets of Ideas and Activities.* Earthscan, London & New York. Available at: https://bit.ly/3qfESso (Accessed: 18.03.2022)

Q.1 - Why do we conduct the workshop?

What is the purpose of the workshop?

- Through the workshops, we seek to investigate the use of *Non-fungible tokens* (NFT) dynamics in traditional board games to understand how such technology can act as design material and enhance user experiences.
- As NFTs are digital assets and board games are physical items, our second aim is to explore how users experience hybrid board games and use this knowledge to further develop our DMB framework.
- **Game 1 - "Builder Brawl":**
    - In the two games, Ludo Brawl and Trivia Brawl, we wish to study the transient nature of NFTs and how players experience a game feature that incorporates this type of functionality.
    - Based on our example of using a transient functionality (i.e., to have and keep a personal game character across multiple games, regardless of the players involved), we also seek to explore the aspect of ownership towards game characters and how NFTs may have/provide sentimental value.
- **Game 2 - "NFTs against reality":**
    - In the second game, we aim to explore the aspect of trading and ownership of NFTs in the traditional board game "Cards Against Humanity".
    - Traditionally the experience of trading NFTs is rather devoid of social intercourse, which we aim to challenge by having participants able to trade / bid with each other in the same social space.

What experience, sharing, analysis, learning or other end is sought?

- As the workshops will be conducted with two diverse user groups: 1) Interaction designers, and 2) NFT enthusiasts, we hope to learn about two different perspectives:
    - NFTs as design material - e.g.:
        - How do NFTs relate to other design principles?
        - In which ways can NFTs contribute to new user experiences in designs?
        - What are positive as well as negative aspects of using NFTs as design material?
        - Etc.
    - NFTs as a part of traditional social board games, e.g.:
        - What do NFT enthusiasts think of integrating NFTs in physical social games?
        - What are their perspectives on moving away from the traditional play-to-earn view?
        - Etc.

Q.2 - How does it fit?

How does the workshop fit into longer-term processes of learning and change?

- These workshops take part in a larger design process and act as an evaluation of the first/second iteration of design ideas. Whether we involve the workshop participants later in our de-

sign process is not determined yet, as we need to consider our timetable and resources along the way.

Q.3 - Who and how many?

Who will the people be?

- Interaction designers
  - Group 1:
    - Helene
    - Alexander
    - Thomas
    - Christian
  - Group 2:
- NFT enthusiasts
  - Group 3:
    - Dino
    - Lars
    - Lasse
    - Rasmus
  - Group 4

How should they be selected, and against what criteria?

- The participants will be selected from our personal networks, the Interaction Design education at Aalborg University, and possibly NFT communities/facebook groups/etc.
- **General criteria:**
  - Each participant should be friends or familiar with the rest of the participants within their group/session to ensure a smooth and friendly discourse.
- **Criteria for Interaction Designers:**
  - The participant studies or works within the field of Interaction Design.
- **Criteria for NFT enthusiasts:**
  - The participant knows what the concept of NFT entails.
  - The participant has prior experiences with NFTs - e.g. visiting the marketplaces, buying or selling an NFT.
  - The participant is interested in NFTs.

How many should there or will there be?

- For each session there should be 3 to 4 participants (more than four may not be possible, due to the Builder Brawl's limitation of players)
- How many will actually show up? consider this afterwards.

Q.4 - What expectations?

What will the participants expect?

- The participants can expect the workshops to be social events, where they play games with their friends and learn about NFTs and Interaction Design.
- They can also expect that snacks and soda will be present, enhancing the game night experience and the social atmosphere.

Q.5 - How participatory?

What sort of process?

- User centered design
- Using the participants insights to further iterate on the low-fidelity prototype and later our final prototype

How participatory can and should it be? How much can participants do themselves?

- The workshop may to a degree be participatory, as the participants will be in control and play the game by themselves We

will only observe and take notes.

Q.6 - What is the part/role of each team member?

What is your role and contribution? Trainer, facilitator, co-learner…?

- The diverse roles includes:
  - **Facilitator**: has the task of facilitating and being "in-charge" of the workshop; describing each workshop activity clearly, helping the participants if they have questions, etc. In case only 3 participants show up for a session, the facilitator can join them as the fourth player.
  - **Observant**: acts as a "second" facilitator, but has the main responsibility of observing the participants, writing notes accordingly, and asking follow-up questions during the session.
  - **Audio/cameraman**: is responsible for recording the workshop sessions, whether it is on audio or camera.
- **Session 1&2 / Group 1:**
  - Mark - Facilitator
  - Marco - Audio/Cameraman
  - Madeleine - Observant/notetaker
- **Session 1&2 / Group 2:**
  - Mark - Facilitator
  - Marco - Audio/Cameraman
  - Madeleine - Observant/notetaker
- **Session 1&2 / Group 3:**
  - Mark - Facilitator
  - Marco - Audio/Cameraman
  - Madeleine - Observant/notetaker

Q.8 - Where?

What venue should be sought, against what criteria?

- The workshops should be held at a place with a social atmosphere, making the game setup more natural At Marco's place.
- No specific criteria, except that it should be convenient for the participants to get there.

Q.9 - When?

When should it be?

- **Date:**
  - Preferably week 13 (28th-31th of March) or 14 (4th of april-10th of April), maybe Friday 25th if possible.
    - **Group 1:** 30th of March
    - **Group 2:**
    - **Group 3:**
- **Time:**
  - In the evening.

How long should it take?

- To fully engage in the games and conduct the reflection activities, we should put aside 2 hours.

Q.10 - Finance

What will it cost and how will it be paid for?

- Our group will cover and share the expenses for the workshop.

What allowances, if any, will participants expect and receive, and who will pay for these?

- The workshop should appear as a traditional game night with snacks, drinks, and a good atmosphere - as such, the workshop participation itself can act as an allowance.

Q.11 - Programme

With whom, where, when and how should the programme be planned? Who should be consulted?

- With our two supervisors

Q.12 - Languages

What languages will be used? Who may be marginalized by language? What can be done about it? Are interpreters needed?

- The workshops will be held in Danish.

Q.14 - Materials and equipment

What will be needed – materials, equipment, transport?

- Materials we will bring:
  - Boardgames
  - Snacks
  - Drinks
  - Camera
  - Computer
  - Consent form
  - Guide to playing the games

Q.15 - Participants' preparation

What should be sent to participants in advance?

- An online invitation, including the place and time for the NFT Game Workshop.

What should they do in advance?

- No, preparation is necessary.

Q.17 - Outputs

What outputs will there be? A written record? A report? A video? Notes? If so, who will be responsible and what will be the later value, circulation and use of the output(s)?

- Video recording, audio recording from a mobile phone, written notes, and possibly some pictures for demonstration purposes in the report.
- IxD group will construct sketch ideas for NFT board games, and discuss them in group
- NFT enthusiasts will write different contexts NFTs can / or are being used.
- The whole group is responsible for the outputs and each member will be coding and analyzing the recording. We will make use of the approach of "process coding".

Q.18 - Follow-up

What follow-up can and should there be? With participants?

- Participants need to be aware and agree beforehand that additional sessions will be required. We have informed the participants that there will be two workshop sessions or more.
- Depending on results of workshops, a follow-up questionnaire might be sent out to participants for further data gathering.

Q.19 - Your preparation

What do you need to do to prepare? When and how can you do this? What help do you need?

- A prototype of each game - Marco
- Consent form, introduction to the project, agenda, (interview questions) - Marco
- Snacks and beverages
- Camera/audio recording equipment - Mark
- Computer/paper to take notes - Madeleine

Appendix B: Introduction and Focus Group questions

English version:

Hi everyone, we would like to start by thanking you all for participating in this NFT Game Workshop - this means a lot to us and our Master's project. As most of you know, we are three Master's students from the education of Interaction Design at Aalborg University. Our Master's project investigates how *Non-fungible tokens* (NFTs) can be further utilized and act as interaction design material, providing new interesting/engaging user experiences that bridges the digital and physical products. To study this, we have focused on hybrid social games and their related affordances, as you will come to experience/see during the workshop.

Based on this problem area, the purpose of this workshop is to get insights into what experiences NFTs bring to traditional board games, how this technology can apply as interaction design material and be further utilized in other cases - seen from both a designers perspective and an NFT enthusiast's.

As such, we would also like to emphasize that all data collected during the workshop remains confidential and is used only for academic purposes. To approve of us recording you on both video and sound, we would like you to sign this declaration of consent. (The participants are given the declaration of consent).

The workshop will last about two hours and during the session we may ask you a few questions or for you to elaborate on specific interactions/ moves. Here, we also would like to underline that there are no stupid answers and if you are in doubt, that is fine. We will try to help each other out.

Agenda

(When the exact time of meeting is decided, we will discuss into more detail how much time should be allocated to each point on the agenda)

- **Welcome the participants**
  - Today's agenda
- **Introduction/presentation**
  - What is our master's project about? Who are we?
  - What is the participants' contribution to our project?
  - Sign the consent form and fill out questionnaire about what they know about NFTs
- **Game 1 - Ludo Brawl**
  - Describing the game and its rules
  - Playing the game

-- BREAK --

(Other breaks may come naturally)

- **Game 2 - Trivia Brawl**
  - Describing the game and its rules
  - Playing the game
- **Focus group**
  - See interviewguide
- **Game 3 - NFTs against reality**
  - Describing the game and its rules
  - Playing the game
- **Focus group**
  - See interviewguide

-- BREAK --

- **Design session (IxD) / Ideation session (NFTer)**
  - 15 minutes of drawing / 15 minutes of ideation and writing down thoughts
  - 15 minutes of critique session / 15 minutes of discussion
- **Ending the session**
  - Thanking the participants for joining our workshop.
  - Describe what our next step is and how we will use their input.
  - Plan the follow-up session?

Focus Group - IxD - Interviewguide

Part 1 - Builder Brawl (Engelsk)

Questions:

Initial and general thoughts:

1. What are your initial thoughts after playing the game…
   a. "Ludo Brawl"?
   b. "Trivia Brawl"?
2. Which of the two types of Builder Brawl did you like the most and why?

NFTs and social interactions:

3. What do you relate to the term Non-fungible tokens? You are welcome to come up with specific examples.
4. How do you understand the use of NFTs in the two games, "Ludo Brawl" and "Trivia Brawl"?
5. Based on your understanding of NFTs, what do you think about the implementation of NFTs in the two games?
6. How do you feel about the social interactions of the game?

Transient:

7. What do you relate to the term "transient"?
8. What parts of the game do you experience as "transient'' in these games?
9. In many online games as well as NFT games, players have a personal character that they foster and advance over a longer period of time. How did you experience having such a transient functionality in a physical game; that you can use and develop your lego character across several games as well as different game platforms?
10. As an interaction designer, can you think of any concepts, designs or ideas where this "transient" design principle is currently being used?
11. As a follow-up to the last question, is there any other contexts that a "transient" design principle can be used?

Ownership:

12. What do you think about the concept of owning specific game pieces (in the form of NFTs) of a physical board game? As presented with the Ludo bricks, in Ludo Brawl.
13. Which of the two games did you prefer when considering how to gain or lose bricks?

Hybridity:

14. Can you think of any hybrid board games that you have played before?
    a. In these games, what elements made it hybrid?
15. What do you think about games that are hybrid, i.e. combining physical and digital parts?
16. What new user experiences do you think hybridity adds to the games, if any?
17. In what other ways may hybridity be integrated into these games?

Closing:

18. Any other comments or additions about the game before we move to the next point on the agenda?

Part 2 - NFTs against Reality

Questions:

Initial and general thoughts:

1. What are your initial thoughts of playing the game "NFTs against Reality"?

NFTs and social interaction:

2. How do you understand the use of NFTs in the game?
3. Based on your understanding of NFTs, what do you think about the implementation of NFTs in the game?
4. How do you feel about the social interactions of the game?

Trading:

5. In consideration to board games, do you recall any associations with trading such as trading cards, figures, or game pieces?
   a. What are your thoughts regarding this kind of game mechanic?
6. How do you think the concept of trading influences the game experience of "NFTs against reality"?
7. What do you think about the aspect of trading, buying, and selling cards to get a better chance of winning?

Ownership:

8. What user experiences do the aspect of "ownership" bring to the game?

Hybridity;

9. What new user experiences do you think hybridity adds to the game, if any?
10. In what other ways may hybridity be integrated into the game?

Closing:

11. Based on our discussions about all three games, what do you as interaction designers believe are the pros of implementing technology such as NFTs into board games?
12. What are the challenges of using NFTs as design material to create new user experiences?
13. As NFTs are digital assets, how do you experience them as physical objects in the three games?
14. What other context or social games may NFT technology be further utilized?
15. Any other comments or additions about the game before we move to the next point on the agenda?

Focus Group - NFT enthusiasts - Interviewguide

Part 1 - Builder Brawl

Questions:

Initial and general thoughts:

1. What are your initial thoughts of playing the game…
   a. "Ludo Brawl"?
   b. "Builder Brawl"?
2. Which of the two types of Builder Brawl did you like the most and why?

NFTs and social interactions:

3. What do you relate to the term Non-fungible tokens? You are wel-

come to come up with specific examples.

4. How do you understand the use of NFTs in the two games, “Ludo Brawl” and “Trivia Brawl”?
5. Based on your understanding of NFTs, what do you think about the implementation of NFTs in the game?
6. What do you think about adding a more personal relationship towards the traditional Ludo game and its bricks by assigning ownership to the bricks through NFT smart contracts?
7. How do you feel about the social interactions of the game?

Transient:

8. What do you relate to the term “transient”?
9. What parts of the game do you experience as “transient’’ in these games?
10. In many online games as well as NFT games, players have a personal character that they foster and advance over a longer period of time. How did you experience having such a transient functionality in a physical game; that you can use and develop your lego character across several games as well as different game platforms?

Ownership:

11. What do you think about the concept of owning specific game pieces (in the form of NFTs) of a physical board game? As presented with the Ludo bricks, in Ludo Brawl.
12. Which of the two games did you prefer when considering how to gain or lose bricks?

Hybridity:

13. Can you think of any hybrid board games that you have played before?
    a. In these games, what elements made it hybrid?
14. What do you think about games that are hybrid, i.e. combining physical and digital parts?

Closing:

15. How would you improve the game in relation to NFTs?
16. Any other comments or additions about the game before we move to the next point on the agenda?

Part 2 - NFTs against Reality (Engelsk)

Questions:

Initial and general questions

1. What are your initial thoughts of playing the game “NFTs against Reality”?

NFTs and social interactions:

2. How do you understand the use of NFTs in the game “NFTs against Reality”?
3. Based on your understanding of NFTs, what do you think about the implementation of NFTs in the game?
4. Can you think of other ways to utilize NFTs in “NFTs against Reality”?
5. How do you feel about the social interactions of the game?

Trading:

6. In consideration to board games, do you recall any associations with trading such as trading cards, figures, or game pieces?
    a. What are your thoughts regarding this kind of game mechanic?
7. How do you think the concept of trading influences the game experience of “NFTs against reality”?

8. What do you think about the aspect of trading, buying, and selling cards to get a better deck?

Ownership:

9. What user experiences do the aspect of “ownership” bring to the game?

Closing:

10. Based on our discussions about all three social games, what do you think about utilizing NFTs further and integrating them in physical social games?
11. As NFTs are digital assets, how do you experience them as physical objects in the three hybrid social games?
12. How would you improve the game in relation to NFTs?
13. What other context or social games may NFT technology be further utilized?
14. Traditional NFT games focus on play-to-earn, but this aspect is removed from all three games. What do you think about the shift from play-to-earn to more social focused NFT games?
15. As a follow-up question to the previous one, what do you think would be the reactions of the NFT community?
16. Any other comments or additions about the game before we move to the next point on the agenda?

Creative Tasks

Design session - Interaction Designers

- How would you change the games?
- How can NFT technology as design material, as you understand it, be utilized in other products?

Ideation session - NFT enthusiasts

- How can NFT technology be utilized in other contexts?
- How can NFT technology be utilized in other existing products or applications?

Appendix C: Consent Form

Consent form

The purpose of this workshop is to gather insights about the integration of NFTs into physical social games. Particularly, the session focuses on how NFT technology can be further utilized and act as design material, providing new engaging user experiences.

By signing this declaration of consent, I comply to:

- Understanding that I can freely ask questions about the project and the methods employed by the Master's students.
- Understanding that the data extracted from the workshop is used only for the Master's thesis and other related academic purposes.
- My participation in this project is voluntary, and I have the right to refuse to participate.
- I can refuse to answer questions without consequences, and I may stop the workshop participation at any time.
- I allow the interview to be video and audio recorded, and understand that the recordings will only be used in this project.

I hereby give my consent to being evaluated and thereby participate in this project.

Signature: _____ Date: _____

Appendix D: Questionnaire

Name:_____

Age:_____

Q1. On a scale from 1 to 7, how much do you know about Non-fungible tokens (NFTs)? **1** being little to no knowledge regarding NFTs and **7** having expert knowledge regarding NFTs.

1	2	3	4	5	6	7

Q2. What do you relate to the term Non-fungible tokens? You are welcome to come up with specific examples.

_____

_____

_____

_____

_____

_____

_____

Q3. What made you interested in NFTs?

_____

_____

_____

_____

_____

_____

Q4. Where have you gained knowledge regarding NFTs? (Example: online articles, blogs, marketplace, etc.)

_____
_____
_____
_____
_____
_____
_____

Q5. What previous interactions do you have with NFTs? You may tick off one or more boxes.

Minting	Buying	Trading	Selling	Bidding	Visiting marketplaces	Reading about the technology	No prior interaction

Appendix E: Focus Group Questions for Evaluation

Preliminary and general thoughts:

1. What are your first thoughts after having played…
   a. "Ludo Brawl"
   b. "Trivia Brawl"
2. Which of the two types of Builder Brawl did you like the most, and why?

Game Cube / NFTS:

3. Could you see yourself bringing a Game Cube like piece to board game nights?
4. Could you see yourself having a Game Cube like piece in your home to represent your NFTs in the physical space?
5. What do you think of the design for the Game Cubes?
   a. What are your thoughts of this type of NFTs, compared to that of the LEGO NFT from the previous version of Ludo and Trivia Brawl?
6. What are your thoughts regarding the interaction of gaining / losing colored dots?
7. What are your thoughts regarding the interaction of placing colored dots?
8. What are your general thoughts on being able to create an NFT, which can be used in other contexts?
   a. Which contexts do you imagine this kind of NFTs could be used in?
      i. Online games?
      ii. Profile Pictures?
9. What are your thoughts on the mini-games?
   a. How did you find the interaction of the mini-games?
   b. Should the games have changed difficulty level depending on

how many colored dots players have?

10. Are there other things you would wish the Game Cube could do?

Game Hub:

11. What are your thoughts regarding the interaction of the Game Hub?
12. What do you think of the design for the Game Hub?
13. How did you experience the feedback of the Game Hub?
14. What are your thoughts on the presentation of questions during Trivia Brawl?
15. Is there other things you would wish the Game Hub could do?

Hybrid Board Games:

16. What are your thoughts of utilizing technology in board games?
17. What do you think of the balance between physical and digital in HYBRIDA?
    a. Are there aspects you would have liked to be more physical / digital?
18. If you could choose something to remove from HYBRIDA, what would it be?
19. If you could choose something to add to HYBRIDA, what would it be?
20. What are your thoughts regarding the overall feedback of HYBRIDA?
21. What are your thoughts about the customizability through the Board Game?

NFT:

22. Which parts did you perceive as transient when playing HYBRIDA?
23. Did you feel a form of ownership towards your Game Cube NFT?
24. Did you have any interest in what the opposite team was making as an NFT?
25. If your NFT were to be presented and used in an online form, what would then be important for you?
    a. Community?
    b. Trading
    c. Events?
26. What are your general thoughts of utilizing NFT technology for new board game experiences?

Concluding

27. Could you imagine other board games that could be transformed into compatibility with HYBRIDA?
    a. Game Cube?
    b. Game Hub?
    c. Board Game?
28. Any concluding thoughts regarding HYBRIDA?