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Development and evaluation of the collaborative three-player game ZooBreak based on game-design theory

Bachelor's thesis in Computer science and engineering

Ludwig Bågenfelt
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Department of Computer Science and Engineering
Chalmers University of Technology
University of Gothenburg
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Abstract

Video games are an important part of society, providing leisure, social connections, and improved problem solving skills. Video games have traditionally focused on competition, but there is a growing demand for collaboration: games where players work together towards a shared goal. This thesis looks at the design challenges of collaborative play between three players. A player count of three adds more complexity compared to two-player games and remains mostly un-explored in existing research. The purpose of this project is to analyze collaborative game design for three players using a *research-through-design* approach. An original game titled ZooBreak was developed, building on a theoretical foundation of game design patterns. The game's levels are based around several collaborative game patterns, notably *asymmetric roles*, *concurrency*, and *asymmetric information*. The game was evaluated through playtesting, where qualitative data is gathered via direct observations and semi-structured interviews with participants. A *thematic analysis* of the data shows how different design choices affect communication and collaboration. The study then concludes that the implementation of *asymmetric roles* and *concurrency* are highly effective for engaging three players, while other patterns, such as *separation gates*, should be used with caution to avoid player frustration. These findings offer design recommendations for the future development of three-player collaborative video games.

Sammandrag

Idag är datorspel en viktig del av samhället. De erbjuder underhållning, sociala kontakter och förbättrad problemlösningsförmåga. Datorspel har traditionellt varit tävlingsinriktade, men det finns en växande efterfrågan på samarbetsspel, det vill säga spel där spelare arbetar tillsammans mot ett gemensamt mål. Detta projekt undersöker designutmaningar i samarbetsspel för tre spelare. Trespelarspel ökar komplexiteten jämfört med tvåspelarspel och är fortfarande relativt outforskade i befintlig forskning. Syftet med projektet är att analysera design av samarbetsspel för tre spelare med hjälp av en *research-through-design*-metod. Ett spel med titeln *Zoo-Break* utvecklas, baserat på en teoretisk grund av speldesignmönster. Spelets nivåer utformas kring flera samarbetsspelmönster, särskilt *asymmetric roles*, *concurrency* och *asymmetric information*. Spelet utvärderas genom speltestning, där kvalitativ data samlas in via observationer samt semistrukturerade intervjuer med deltagare. En *tematisk analys* av datan används för att undersöka hur olika designval påverkar kommunikation och samarbete. Studien drar slutsatsen att implementeringen av *asymmetric roles* och *concurrency* är särskilt effektiva för att engagera tre spelare, medan andra mönster, såsom *separation gates*, bör användas med försiktighet för att undvika frustration. Dessa resultat ger designrekommendationer för framtida utveckling av samarbetsspel för tre spelare.

Keywords: collaboration, cooperation, video games, game design patterns, research trough design, thematic analysis

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Ludwig Bågenfelt, Alexander Hyyppä, Endre Jansson, Linda Jonsson, Egil Morén, Ebba Munck, Gothenburg, June 2026

Contents

1

Introduction

Video games are an important part of society and have a significant cultural impact [1]. They function as leisure activity, stress relief, and provide social connection, but also support education, increase cognitive performance [2], and improve intelligence [3]. Traditionally, games have been competitive, but there has been a significant increase in demand for collaborative games [4], in which players work together to achieve a common goal. Collaborative games have several advantages compared to competitive games, including the behaviors and attitudes they promote and the potential to attract a broader audience. Collaborative games can, for example, promote prosocial behavior [5], relationship quality [6], team work effectiveness [7], and communication skills.

This thesis will explore the process of developing a collaborative video game, by implementing an original game and evaluating it through a research-through-design approach along with player testing.

1.1 Background

In recent years, there has been a surge in popularity of collaborative multiplayer games, such as *Lethal Company*[1] and *PEAK*[2], which are accessible and affordable games whose main focus is playing with friends. For these games, communication between players is a central theme or mechanic of the game, often implemented through proximity chats. The number of players in these games are usually flexible and can be decided by the size of the group who wants to play.

The intended number of players is highly relevant when designing a game. Increased group size has been shown to have a negative effect on communication [8], and for collaborative games, a smaller group size is expected to increase contributions from each team member [9]. Therefore, there is a challenge in creating games for a larger group of people, due to the bigger requirements of making sure each player feels important and all players can communicate effectively.

Some games are well suited to a varying number of players; adding or removing players may increase or decrease the difficulty of these games, but they still function fundamentally the same. Some cleverly designed games manage to offset the pros

[1] Zeekerss, *Lethal Company*, 2023.
[2] Aggro Crab and Landfall Games, *PEAK*, 2025.

and cons of adding another player in such a way that the balance is mostly unchanged [10]. However, other games are completely tied to a fixed number of players, and changing the number of players would require the game to be re-designed. Notable examples of this are games that use *asymmetric roles* (see 2.4.4) where all different roles are needed. Games with *asymmetric roles* are inherently hard to balance, and changing the number of players can disrupt the entire system [11]. Another example is puzzle games, where the tight level design often hinges on precise interactions with the player. This often means that removing a player would make the puzzle impossible to solve and adding a player can break the intended solution or even circumnavigate the puzzles entirely [12].

Games with a fixed number of players have the advantage that the game design can be tailored specifically to that player count. This also allows each player to be assigned unique abilities that are necessary to complete the game. Such design encourages interdependence between players, which has been shown to increase social closeness [13]. Several popular multiplayer games are built around this concept for two players, such as *It Takes Two*[3] and *Split Fiction*[4]. Games designed specifically for three players are less common. One example is *Trine*[5], a game designed around three different characters with different abilities, all needed to solve puzzles and complete the game. Although the game can be played by a single player controlling all three characters, it also supports three players controlling one character each.

Designing a game for three players is interesting because the research of collaborative game design for three players is lacking. Compared to two-player collaborative games, three players introduce more complexity and design challenges. Some challenges are, for example, how to design a game that allows interactions between all three players simultaneously, so that no one works alone or feels less included or important.

1.2 Purpose

The purpose of this thesis is to explore collaborative game design for three players with a research-through-design approach [13]. This will be done by creating a collaborative multiplayer video game and evaluating its design elements using user playtesting. The results may serve as guidance for future projects of designing collaborative games for three players, including recommendations on effective and ineffective design choices. When designing the game, collaborative game patterns will be used (see section 2.4), which will then be evaluated or further developed and adapted to suit three-player games.

[3]Hazelight Studios, *It Takes Two*, Electronic Arts, 2021.
[4]Hazelight Studios, *Split Fiction*, Electronic Arts, 2025.
[5]Frozenbyte, *Trine*, 2009.

1.3 Problem definition

The main research question is: what should be considered when designing a three-player collaborative game? This question will be continuously researched using an iterative process of designing, testing, and evaluating. The project also explores what game elements support communication, interactions, and a balanced gameplay among all three players, as well as which elements hinder collaboration (by, for example, causing confusion, frustration, or boredom).

1.4 Limitations

This study addresses the research question by evaluating our own game through observations, player interviews, and analysis of the design process, rather than comparing it with other games. Additionally, the results will be limited to qualitative data and the methods for game evaluation will aim to understand, not measure, the behavior and experience of the players (as explained in section 2.6). Therefore, no quantitative conclusions will be pursued and the generalizability of the results will be limited. The applicability of the findings will primarily consist of general insights and design recommendations regarding what is likely to work effectively and what is less likely to do so.

The game is developed as a local multiplayer experience where players sit in the same physical space and play on the same network on different devices. While the game's design might theoretically support online play, implementing online networking and accessibility features was deemed beyond the project scope due to time and resource constraints. Furthermore, local play allows for social interactions, such as facial expressions, that might be lost in an online-only environment. Thus, the results of this study may be affected by the variety of communication methods available to the study participants [14].

The results of the study will also be limited by the demographic of the sample. The study participants mostly include students from Chalmers University of Technology. This means that the results may be mostly accurate for game development for a target audience of young, educated adults. The fact that some playtesters will be relatively knowledgable about games and game design will also affect the results.

Another limitation is that the research group conducting this study has limited prior experience of game design. Therefore, some aspects of the game's quality might interfere with the communication between players and lead to inconclusive or unreliable results.

2

Theory

This chapter presents the concept of game design, collaborative games, and game design patterns. Further, it describes a few game design patterns in detail that are relevant for this study, and explains the core principles of game evaluation as well as thematic analysis.

2.1 Game design

Game design is a broad concept with multiple perspectives and definitions. One perspective defines game design as a player-centric approach where the focus is on the player experience [15]. In this perspective, being a game designer is about designing the specific experience the player will have and acting as an advocate for the player. This includes gameplay elements, sound design, graphics, and other aspects that can shape the player experience. This study mainly focuses on the gameplay elements and player interactions.

To support the design and analysis of gameplay experiences, game designers can rely on several established tools and frameworks. One commonly used framework is the *MDA framework*. MDA stands for *Mechanics*, *Dynamics*, and *Aesthetics*, and is a common way of analyzing how different elements of a game interact and influence each other. The *mechanics* refer to the actions the game allows players to perform and the underlying implementation. The *dynamics* are the different behaviors that arise from the *mechanics*. The *aesthetics* are the feelings evoked in the player by the *dynamics*. Together, they describe how the different parts of a game inform each other [16].

Within this framework, recurring gameplay interactions and structures can be identified and analyzed as gameplay patterns. In this study these recurring patterns will be referred to as game design patterns.

2.2 Game design patterns

When designing or analyzing a game, game design patterns are used to describe recurring motifs or design solutions in game implementations. These patterns can refer to concrete gameplay elements, such as *boss monsters* and *power-ups*, as well as more abstract design concepts, such as *diminishing returns* or *imperfect information* [17]. Furthermore, there are certain game design patterns that are specifically

relevant for collaboration, which is expanded on in section 2.4. These patterns, as defined by Björk and Holopainen [17], are often not a concrete enclosed part of a game, but each pattern either instantiates[1] or modulates[2] other patterns, and is instantiated and modulated by other patterns as well. Therefore, in this study, the main focus will be on game design patterns which encourage collaboration and social interaction, while more patterns will emerge as a side effect of implementing those collaborative patterns.

2.3 Collaborative games

2.3.1 Definition

A problem in collaborative game studies is the inconsistent use of the words *cooperation* and *collaboration* [18]. Although some studies use the terms interchangeably, in this project they are distinguished by defining a *collaborative game* as one in which all players must work towards a shared goal. In a *cooperative game* on the other hand, players have individual goals, but can choose to help others, usually only when doing so also advances their own goals (*synergistic goals*) [19], [20]. Based on these definitions, some examples of collaborative games are *Overcooked*[3] and *The Gang*[4], where all players have a shared goal of winning the game together. Some examples of cooperative games are *Catan*[5], *Rust*[6] and *Diplomacy*[7], where players have individual goals but can cooperate in order to increase their individual chances of winning [18].

2.3.2 Effects of collaboration

Collaborative games have been shown to have a positive effect on players. In a study presented by Depping and Mandryk [14], two metrics of a collaborative game are presented: collaboration and interdependence. That study shows that these are two separate metrics that do not correlate with each other. Collaboration is present in a game when all players have a shared goal. Interdependence measures how much the players depend on each other. These metrics have been shown to increase enjoyment, social closeness and trust.

Interdependence between players promotes communication, which is why it helps encourage social bonding between players [14]. For interdependence to have this effect, there has to be support for player communication. This means that players should be able to communicate verbally, with body language, or through text. This can be achieved by letting players be present in the same room, or allowing them to communicate online via voice or text messages. For co-located multiplayer games,

[1] Implementation of one game design pattern causes another to be introduced.
[2] Implementation of one game design pattern affects another, causing the gameplay to change.
[3] Ghost Town Games, *Overcooked*, Team17, 2016.
[4] J. Cooper and K. Heath, *The Gang*, KOSMOS, 2024.
[5] Klaus Teuber, *Catan*, KOSMOS, 1995.
[6] Facepunch Studios, *Rust*, 2018.
[7] A. Calhamer, *Diplomacy*, Wizards of the Coast, 1954.

studies have shown positive effects on player experience, including lower levels of aggression and higher feelings of competence compared to mediated play settings. These effects may stem from the immediacy of face-to-face communication, which involves fewer limitations than mediated communication [21], [22].

In general, the social aspect of multiplayer games impacts the player experience. The relationship between players is a relevant factor, with studies showing that playing with friends tends to leave players feeling more enjoyment and spatial awareness compared to playing with strangers [21], [23]. Additionally, the emotions each player experience has a contagious effect. When one player is having fun, that positive energy often spreads to the rest of the group. Likewise, when one player becomes frustrated, it is likely the other players will feel frustrated as well. Thus, the experience for a single player can affect the experience of the entire group [24].

Designing collaborative games comes with different challenges compared to single-player games. Zagal et. al. [19] present some pitfalls they noticed while studying a collaborative board game. The first pitfall is to offer good reason to collaborate in order for there to not be a single player making all decisions. The second pitfall is to have players care about the outcome of the game in order for it to be interesting. The third is to make the player experience different between play sessions to allow replayability.

2.3.3 Collaboration and group size

Games can be designed for different numbers of people, and when deciding this, it is important to consider the psychosocial effects of different group sizes to determine what effects are appropriate for the desired game experience. Previous studies have found that increasing the size of the group has a negative effect on communication quality [8]. In a group of three compared to six members, discussions in the smaller group were perceived as more effective, appropriate, and with greater openness to different ideas and perspectives. To reach high engagement of each participant in group discussions, such as when strategizing or solving puzzles in collaborative games, a small group is more optimal. This is because, in addition to higher communication quality, a smaller group can increase the number of ideas each person provides, and heighten the participants' feelings of involvement and responsibility, while decreasing the number of conflicts [8].

Group size is also theorized to affect psychosocial aspects such as how much social pressure and social incentive participants feel, and that this impacts how willing people are to contribute and cooperate. However, it has also been shown that there is no simple correlation between cooperation and the size of the group. In a study of a voluntary contributions mechanism (VCM) game, the size of the group had both positive and negative effects, depending on conditions that made cooperation more or less favorable [9]. In conditions that are favorable for cooperation (high return), a negative effect of group size is expected, and in unfavorable conditions, a positive effect is expected. This is explained by social pressure and incentive being more important to motivate cooperation and contribution in unfavorable conditions, and that the pressures increase with the group size. However, for collaborative games the

conditions are assumed to be favorable since there is typically no significant conflict between private and collective interests. Therefore, contributions in collaborative games would be expected to increase with smaller group size.

2.4 Collaborative game design patterns

Collaborative game design patterns are game design patterns that are used to incentivize players to work together (for example, by strategizing, sharing knowledge, or timing actions) to achieve their common goal. The patterns defined below are based on the definitions stated by Rocha et. al. [20], Björk and Holopainen [17], Harris et. al. [25], Reuter et. al. [4], and El-Nasr et al. [26].

2.4.1 Shared goals

Shared goals is a collaborative game mechanic in which players work together towards a common goal [20]. For example, one shared goal of a collaborative game could be to complete a game level together. This pattern is essential for collaborative game design, since it is what encourages players to collaborate.

Shared goals differ from *synergistic goals*, where players each have individual goals, but these goals are formed so that following them will inadvertently help the other players achieve theirs [20].

2.4.2 Team play

This pattern entails having a group of players coordinating in the game to reach a common goal or manage a shared resource [17]. Thus, with the utilization of the *shared goals* game design pattern, team play will naturally occur. Teams can either be explicitly defined by the game or emerge as a result of player actions. As an example, a football game has two formalized teams, each team having the common goal of winning the game. Within these explicitly defined teams, there might naturally emerge additional division into subgroups if a conflict arises.

In *team play* it is important to let each member of the team play an important role, so all players feel like they have influence on the success of the group.

For a group of people to collaborate, they need to have a group identity. Having a baseline shared goal, or putting the players against the game system, is one way to obtain this shared identity. However, having even stronger group identities has been linked with greater trust and effort in groups [14]. Strengthening this identity can be as simple as giving the game avatars a cohesive aesthetic.

2.4.3 Social interaction

This pattern refers to the presence of two-way communication between players [17]. This communication can be verbal or visual, and be supported in-game, by third parties, or by having players be physically present together. Some examples of ways for players to communicate is by talking, or using their game avatar to portray body

language. In general, having the shared game state is also a way to communicate since it allows players to take actions that have a significant impact on other players [17].

2.4.4 Asymmetric roles

In collaborative games it is common that different players will perform different tasks, and thus have different roles. The roles can emerge naturally during play (*emergent roles*) or be explicitly determined by the game itself. A game in which players have unique ways of interacting with the game has *asymmetric roles* [25]. A game might assign players different roles by giving the players different abilities (*asymmetric abilities*), or by placing them in different locations. The roles, or abilities, bestowed upon the players usually complement each other and make the group strong together. A benefit of *asymmetric roles* is that players with differing preferences or skill levels can choose roles that suit them [27]. The *asymmetric roles* pattern has the main effect of increasing interdependence between players, meaning it encourages communication and coordination.

When designing a collaborative game, it is important not to have one player making all decisions, since the game ultimately becomes a single-player game [19]. One way to combat this is by utilizing the *asymmetric roles* game design pattern. It enforces collaboration by having each player be an expert of their own abilities, and therefore play a vital part in the progression in the game.

2.4.5 Concurrency

Concurrency occurs when at least two players simultaneously operate on one or more shared objects in a way that would not be possible for a single player alone [4]. By requiring players to coordinate their actions, this pattern encourages communication between them.

The use of *concurrency* in games can affect immersion, since it can be recognized as artificial if the design choices are nonsensical. For example, a door that requires two separate buttons to be pressed simultaneously in order to open it may appear impractical under normal circumstances [4]. However, similar mechanisms can feel more believable when based upon real-world practices, such as two-person integrity systems used to increase security [28].

2.4.6 Shared puzzles

Shared puzzles are puzzles in a game that are designed for collaborative play, where players encounter a shared obstacle they have to overcome together [26]. These obstacles are concrete parts of a game, such as a puzzle that must be solved for the players to progress. This pattern encourages players to work out strategies together and help each other. Although, it has the drawback of possibly causing players to have to wait on each other, which can be a cause of frustration for the players [25].

2.4.7 Asymmetric information

Similarly to *asymmetric abilities*, *asymmetric information* entails giving the players access to different information. When combined with a puzzle, *asymmetric information* can encourage communication by requiring players to share and explain their individual pieces of information to one another to solve the puzzle [25].

2.4.8 Separation gate

The concept of a *separation gate* is a design choice in which players are separated in the game, usually by not allowing players to progress unless they split up [4]. This pattern is implemented by only allowing certain players to reach certain areas. For example, players may need to pass through a door that only remains open while a button is pressed, forcing one player to stay behind to keep the door open. One potential drawback of this pattern is the possibility of inducing hesitation in the player left behind due to being separated from the others [4].

2.4.9 Gathering gate

The opposite of a *separation gate* is a *gathering gate*, which forces players to gather in certain locations, only allowing them to progress after they are together [4]. If one player is faster or slower than another, it may force players to wait for each other, which can cause frustration.

2.4.10 Camera settings

The *camera settings* for a collaborative game is also a game design pattern. In a study by El-Nasr et al. [26], three camera settings for a shared-screen collaborative game were identified: *split-screen*, *one character in focus*, and *all characters in focus*. The *split-screen* camera setting is where the screen is divided into equally large sections, each section displaying the view of one player. The *one character in focus* pattern means that the camera follows a single player, and the other players are forced to stay within that camera view. The *all characters in focus* pattern means that all player characters remain visible on the screen at all times. To achieve this, the camera dynamically adjusts its position and zoom level, for example by zooming out when players move apart. In the study, it was shown that the *split-screen* and *one character in focus* camera settings induced situations where players were forced to wait on each other or got in each other's way. These events can cause frustration for the players [26].

Related to camera setting, the setting in which the game is to be played also affects collaborative metrics. As an example, if players have individual views of the game using separate devices, it can cause confusion of which player controls which character in the game, as well as reduce the possibility for players to learn from each other [24].

2.5 Research through design

Research through design is a practice in the field of human-computer interaction (HCI) [13]. The application of this method aims to aid design researchers in answering research questions by having them create artifacts as part of the research process. These artifacts can be utilized for exploring new ideas and concepts by making them and evaluating them with user evaluation [13]. Research through design is a broad term with a lack of standardized definition, however, the goal of the approach is to acquire knowledge, not a final product [29].

2.6 Data gathering for games

Data gathering for collaborative multiplayer games aims to evaluate whether or not the game satisfies the intended effects, such as social metrics and overall experience [24]. The methods for evaluating games do in many ways follow the methods applied to the general topic of interaction design. Data gathering in the context of interaction design aims to identify requirements for a product being designed, or to evaluate how users interact with a system [30]. User feedback, also referred to as user elicitation, is the process of collecting opinions and experiences from the target user group regarding a product. Involving users throughout the development process helps ensure that the resulting product meets user needs and expectations. Relying solely on evaluations conducted by developers and product owners does not guarantee user satisfaction, as their perspectives may differ significantly from those of the intended users [30].

In the context of computer games, the user ultimately decides whether or not a game is successful. Steve Bromley from Games User Research [31] describes four main approaches to collecting user feedback:

- **Observation:** direct study of player behavior. Observations are effective in understanding players' behaviors.
- **Interview:** ask the players questions about their playing experience. Interviews work best for understanding the players' opinions.
- **Analytics:** quantitatively measure behavior, for example by tracking how long it takes for a level to be completed. Analytics work well to measure the players' behaviors
- **Surveys:** structured collection of opinions from a larger number of participants. Surveys are effective at measuring the players' opinions.

These methods serve different purposes depending on whether the goal is to understand player behavior or player opinions.

2.6.1 Identifying participants

Selecting participants for data gathering is a key part of the process. There are two main ways of choosing participants from a study population, either probability

sampling or non-probability sampling [30]. Probability sampling entails selecting participants from a study population at random, either from the entire population, or by first dividing the population into categories and selecting at random from those groups. Non-probability sampling means recruiting participants who are willing to participate. One category of non-probability sampling is convenience sampling, where participants are people who were available rather than specifically selected. Probability sampling allows for generalization to the broader population, whereas non-probability sampling does not support such generalization.

2.6.2 Relationships

Before data gathering, it is important to clarify the relationship between participants and data gatherers, for example with a consent form [30]. This form usually tells participants how the data will be collected and how it will be presented to the public. It is intended to clarify to the participants how their data will be handled, while assuring the data gatherers that the participant is willing to have their data used in the way intended.

2.6.3 Data recording

Capturing data of a user evaluation can be done in multiple ways. Mainly, one can either observe the study participants, or actively interview them [30].

Taking notes is a flexible way to record observations, although it enables biases due to the data gatherers selectively evaluating what information is relevant or not, and therefore might miss noting observations that could be relevant. Having multiple people taking notes of the same observations may mitigate this risk [24]. Audio recording is also a useful tool since it reduces the need for the note-takers to write down everything they observe, further mitigating the risk of missing relevant observations. Another way to capture data is with video recordings. For this method, it is relevant to decide what parts of a study are relevant to record, such as the product and the participants themselves. It is also relevant to take note that intrusive video equipment may affect user behavior, thus impacting the results of an observation [30].

Interviews can be conducted in four main ways: structured, semi-structured, unstructured, or in focus groups [30]. Structured interviews have questions that have a set amount of pre-defined answers, also called closed-ended questions. Unstructured interviews contain questions which enable the interviewees to answer freely, meaning the questions are open-ended. Semi-structured interviews combine elements of a structured and unstructured interview by having both open-ended and closed-ended questions. Open-ended questions are effective when the aim of the data gathering is to explore different answers, while closed-ended questions are more appropriate when all possible answers are known [30]. The questions should be crafted with the intended game experience in mind, so the participants can respond to questions related to metrics that are relevant to the intended evaluation outcome [24].

2.7 Data analysis

Data can either be qualitative or quantitative [30]. Quantitative data is data which can be converted into numerical results. Qualitative data is data such as words and images. Both quantitative and qualitative data can be collected from any type of data gathering (interviews, recordings, etc.). Analysis of quantitative data will give numerical results, such as statistics, whereas analysis of qualitative data will give resulting patterns and themes.

2.7.1 Thematic analysis

One type of qualitative analysis is thematic analysis. Braun and Clarke define thematic analysis as "a method for identifying, analyzing, and reporting patterns(themes) within data." [32, p. 79]. Further, they state that "A theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set." [32, p. 82]. The process of performing a thematic analysis of gathered data is iterative. After conducting an initial analysis of the data, themes are to be identified in the data gathered [30]. The data is then reanalyzed with a more systematic approach, by investigating whether the themes occur across all gathered data or not. Once identified, the data and themes are further examined to see if any overarching themes can be identified, how themes relate to each other, and which themes might be irrelevant.

3

Method

This chapter presents the tools and methods used during the development of the project. Following a research-through-design approach, a game based on theory behind collaboration and collaborative game design patterns was developed and evaluated. A combination of literature review, agile development practices, and iterative design was applied to support both the creation and evaluation of the game. Appropriate software tools, version control systems, and testing procedures were also selected to enable efficient collaboration and continuous improvement throughout the development process.

3.1 Literature review

Earlier research on collaborative game design was reviewed to identify what design approaches work or hinder player collaboration. Research on game design patterns and their impact on collaboration guided the direction of the game. This research was discovered through academic databases such as Web of Science [33], ACM Digital Library [34] and ScienceDirect [35], as well as additional sources provided by the supervisor of this study.

3.2 Version control

In order to be able to work on the implementation of the game simultaneously on different devices, an appropriate choice of version control system was needed. GitHub [36] was chosen as the hosting platform for storing the project files because of its familiarity within the group.

3.3 Game engine and network

The game was developed using the Unity game engine [37]. This was chosen over other engines due to prior experience within the group, ease of use, and it fit the scope of the project. Within the engine, the Netcode for Gameobjects (NGO) [38] framework was used to handle the network side. NGO was chosen over other frameworks due to its clear integration within the Unity game engine and its suitability for implementing multiplayer functionality. It was also recommended by a professor at Chalmers teaching game design.

3.4 Audio design

To compose and produce the soundtrack of the game, a Digital Audio Workstation (DAW) was used [39]. While many DAWs are subscription based and offer extensive sound libraries and advanced tools, the free DAW LMMS (originally an acronym for Linux MultiMedia Studio [40]) was chosen in order to avoid additional costs.

3.5 Workflow

A form of agile workflow [41] was used throughout the development process. With the use of GitHub's kanban board, tasks could be organized into sprints. Each week was defined as a sprint, and updates on tasks from previous sprints as well as the assignment of new tasks was done at the beginning of each sprint. The contents of the tasks can be categorized as game mechanics, level design and UI. Tasks were given out depending on the developer's insight and knowledge within game development, e.g game logic, level design or UI. The tasks were created with a modular mindset, meaning tasks could be worked on parallel to each other without affecting one another. This ensured a more effective workflow within the team and prevented merge-conflicts between git branches. Given this system, team members would quickly become experts within certain areas of the game, such as animations, door functionality, etc. As a result, team members would ask each respective "expert" when necessary.

In parallel with agile workflow, a feature-branch Git workflow was adopted [42]. Typically, a new branch was created for every task and later merged into a combined developer branch, a branch with the latest game version. Developing in Unity comes with a specific issue when working in a scene with others, namely difficult merge conflicts. As a workaround, individual scenes were made for each developer, which was treated almost as a personal space within the group. This and adhering to the modular task creation in agile, ensured a smooth version control workflow.

3.6 Iteration process

The design of the game used an iterative process with four phases. Each phase describes different stages of development and planning of the game. These phases help to set goals that can later be evaluated, with the result of stepwise improving and refining the game based on the evaluations. After fulfilling these goals, the process is repeated beginning on phase one. The four phases are Requirements, Implementation, Testing and data gathering, and Evaluation. In total, two iterations were performed.

3.6.1 Requirements

Requirements of the game were thought of firstly by defining the "frame" for the game, e.g. number of levels and players, basic functionality. For more advanced

requirements, research was made around game design patterns that seemed useful for collaboration or merely practical for games in general. In order to structure the requirements for a smooth work process, the MoSCoW method was utilized. The method involves identifying features into two categories, functional and non-functional requirements [43]. In turn, they are split up into *must haves, should haves, could haves* and *won't haves*. *Must haves* are features and qualities that are vital for the game to function. *Should haves* are features and qualities that aren't strictly necessary, but still important. *Could haves* includes features and qualities that would be nice to have, but are not of as high importance as *should haves*. *Won't haves* specify features that would not be included in the game [44]. The requirement planning helped guide the development process and helped clarify what features were necessary and what should be prioritized.

3.6.2 Implementation

Implementation is done based on the requirements given. Different mechanics, collaborative game design patterns and goals that should be implemented were set in the requirements. The implementation was then performed incrementally based on the agile workflow procedure given earlier. The result was both a playable prototype and some low-fidelity paper prototypes, which served as a framework guiding the development of the playable prototype during the iteration.

3.6.3 Testing and data gathering

A testing phase was deployed after the implementation stage, where a test was done on subjects who had been elicited by convenience sampling [30] and systematized into groups of three. There were two groups in the first iteration and four groups in the second. The group of three subjects played the current version of the game together in the same room while being observed by three researchers. The test subjects were able to communicate both verbally and physically by being in the same room. There were three researchers observing the session, both so there was larger coverage for the observations of each test subject, and to avoid the risk of bias in the observations. One of the subjects' computer recorded screen and audio for later deeper analysis by the researchers. After the playtest, each subject was interviewed by a project member individually.

3.6.4 Design evaluation

At the end of each iteration, the team evaluated the results of the playtest by analyzing the different data gathered from the recent playtests. The data was analyzed in two ways:

1. How participants experienced and engaged with the prototype, and what design insights could be derived from these interactions.
2. What bugs emerged during the playtest and needed to be fixed before the next playtest.

The insights gathered from the evaluation were then carried over to the next iteration to guide the requirements process, and the cycle was repeated.

3.7 Data analysis

The data collected from the playtests was analyzed qualitatively through thematic analysis. For each playtest, the observations and interview answers were summarized, and recurring themes identified. The themes were then noted down in a table to give a clear overview of the results across groups and playtests.

3.8 Usage of AI

The AI tools ChatGPT[1] and GitHub Copilot[2] were used throughout the coding phase of the project to help with debugging of game code, and implementation of the game's network functionality. These tools enabled effective learning for the researchers, whose prior knowledge of game implementation was limited. It significantly decreased the time required to find and learn new ways of implementing game features, enabling the researchers to focus on the parts most relevant to the study, namely game design. Additionally, the built-in tool Writefull[3] in Overleaf as well as ChatGPT were used as grammatical aid in this report. The prompts sent to ChatGPT were one or a few sentences from the written report, followed by instructions such as "Help improving readability of this".

[1]OpenAI, *ChatGPT*, 2026. OpenAI. [Online]. Available: https://chatgpt.com/
[2]GitHub, *Copilot*, 2026. GitHub. [Online]. Available: https://github.com/copilot
[3]Writefull, *Writefull*, 2026. Writefull. [Online]. Available: https://www.writefull.com/

4

Process

In this chapter, the execution of the method is presented in further detail. First, the ideation process is explained, followed by the prototyping stage. The chapter then covers the game development, playtesting, and data analysis.

4.1 Research

Prior to the game development, extensive research was done on the topics of collaborative games as well as game design in general. The articles read have covered areas such as how to encourage collaboration in games, common pitfalls of designing collaborative games, and game design patterns [19], [17]. With a theoretical background on the subject obtained, the researchers played three collaborative games. This was done to gain inspiration and to analyze some already existing games' utilization of collaborative game design patterns, before moving on to the ideation phase. Two of the games were physical card games, *The Gang*[1] and *Hanabi*[2], while the third was the collaborative video game *Overcooked 2*[3], all of which were analyzed to better understand collaborative mechanics.

4.2 Ideation

4.2.1 Brainstorming

After doing research on collaboration in games, a brainstorming stage was deployed to decide the genre and theme for the game. With thorough discussion, the genre of a puzzle and escape room game was selected, where players need to collaborate on various puzzles on different levels to reach the end goal of escaping. This genre was chosen because it allows multiple collaborative patterns to be introduced. These patterns were for example asymmetric roles, concurrency and asymmetric information. It also enables flexible extensibility, since the addition of new design patterns could be done by adding levels, rather than changing existing ones. Alongside this, it was decided that *asymmetric roles* would be an overarching game design pattern used in the majority of the game. This was done since giving asymmetric abilities to

[1] J. Cooper and K. Heath, *The Gang*, KOSMOS, 2024
[2] A. Bauza, *Hanabi*, 2010
[3] Ghost Town Games, *Overcooked 2*, Team17, 2018

players in collaborative games have been shown to effectively encourage collaboration and help ensure that each player has a vital role [27], which is a core challenge in designing a collaborative game.

Soon after selecting the genre, the theme of zoo animals breaking out from a zoo came to mind. This was found to be suitable since it naturally introduces *asymmetric roles* by having each player be a different animal with different abilities.

So, the final concept chosen was a puzzle and escape room game, which follows the story of three animals in a zoo. The players' shared end goal is to escape together. They will pass through various areas of the zoo by entering different levels, which feature different puzzles designed to implement certain collaborative game design patterns.

Although the game's theme could be perceived as sensitive or as an oversimplification of issues related to animals in captivity, the research group determined this was not a relevant problem since the levels would be unrealistic and remind the player less of actual animal cages and more of escape rooms with animals in them.

4.2.2 Selection of animals

The entire game was intended to be dependent on the players having *asymmetric roles*. Which animals and abilities would complement each other the most were thoroughly considered. With discussion, the following animals and abilities were selected:

First, a gorilla, which is big and strong. With it being the largest out of the three animals, it cannot move as swiftly as the others. It has the unique ability to carry and throw objects, such as rocks, as well as the meerkat player. Second, a penguin, which is medium sized and can swim. Due to the penguin being the only animal with the ability to swim, it can reach areas the others cannot. Third, a meerkat, which is small and agile. It has the ability to jump and climb, meaning it can reach higher than any other animals. The different sizes of the animals were selected to make it easier to differentiate the them. It also further enforces the asymmetric abilities of the players, and can be utilized as a method to separate the players at a separation gate.

Initially only the gorilla and meerkat had a shared ability, namely the gorilla's ability to throw the meerkat. The ideal design would be to have each pair of animals share one ability, since it would increase interdependence and therefore encourage collaboration even further [14]. These abilities would have to be chosen so that they do not overshadow or diminish the gorilla-meerkat ability. Due to the possible added complexity by adding more interactions between players, it was prioritized to start implementing the game with only the gorilla-meerkat ability, with the possibility of adding more two-player abilities later.

4.2.3 Player location and camera settings

The design of a collaborative game is highly dependent on where the players are located relative to each other. The main concern is whether they are in the same room (co-located) or not (mediated), and if they are able to see each other's screens.

Early in the ideation phase it was decided the game would be played with all participants in the same room. This was to avoid having to implement online play functionality, since it would be time consuming. This enables the participants to interact with each other face-to-face, which has been shown to have a larger positive affect on the player experience in multiplayer games compared to playing online [23].

Camera settings were another important design consideration. Since the game in this study was intended to implement the *asymmetric information* pattern, the most suitable approach was for each player to have an individual screen displaying only their own character. This reduced the risk of one player accessing all available information and solving puzzles independently. However, certain multiplayer camera setups can negatively affect the player experience. In particular, *split-screen* and *one character in focus* patterns in shared-screen games, as well as games played on separate devices, have been associated with frustration and confusion among players [26], [23]. Despite these potential drawbacks, the game was designed for separate devices to ensure proper implementation of the *asymmetric information* pattern.

To reduce the risk of players losing track of each other and thus being confused [23], each player was given a top-down view of their character and the surrounding area. This provided a personal view of ongoing tasks while still allowing players to see teammates and nearby puzzles.

4.3 Prototyping

In order to explore what level designs would be most appropriate for the project, prototypes were created to visually simulate the flow and theme of each level. They were created using an iterative process, with each new design building on desired features of a previous version.

4.3.1 The concepts behind the levels

Level design is an important part of game development. Levels should be engaging, entertaining, and offer an appropriate amount of challenge to keep players interested [19]. In the case of developing a collaborative game, designing each level to encourage collaboration is another factor to account for in the level designs. To better understand how collaborative game design patterns encourage collaboration and how users experience each pattern, the levels were designed so that each level had one main collaborative pattern in focus.

Level 1 is the tutorial level. The main pattern in focus here is the *asymmetric roles* of the players, which will be used throughout the game. All team members created their own prototypes for the level, until a final prototype was settled upon (see

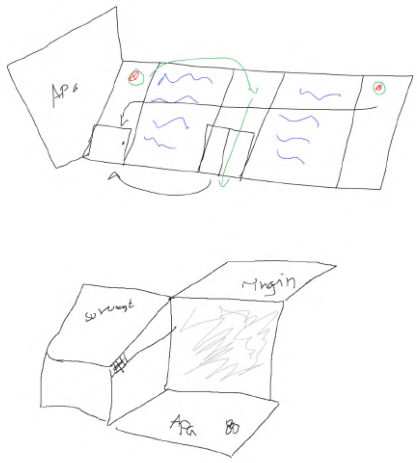

Figure 4.1: Prototype for level 1

Figure 4.1). It was designed so that all players start alone in their individual cages. Each player now has to use their abilities on their own to escape their cages, and the players eventually end up in the same place. Lastly, they use their abilities together to progress to the next level.

Level 2 focuses on *concurrency*, where players have to step on pressure plates together at the same time to open the exit door to reach the last level. The level includes multiple animal enclosures with *separation gates*, where the players have to go back and forth between cages to unlock the required pressure plates.

Level 3 introduces the players to the *asymmetric information* pattern. Through the *separation gate* pattern, the players are separated into separate areas of the level. The meerkat has to travel through a maze to find a button which opens the final exit door. The maze has numerous closed doors and dead ends. The penguin has access to a map (see Figure 4.2) that indicates the route the meerkat must follow in order to unlock the zoo gates. The gorilla has pressure plates that can open the closed doors in the maze, with each tied to the color of the symbols. The aim of this level is to encourage communication between the players by requiring them to coordinate their actions while not being able to see each other in the game.

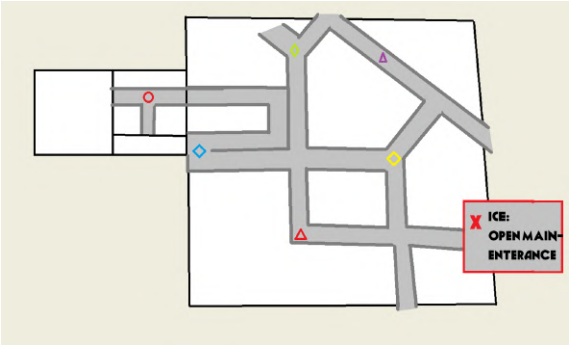

Figure 4.2: Early design of the map the penguin sees to guide the meerkat in level 3

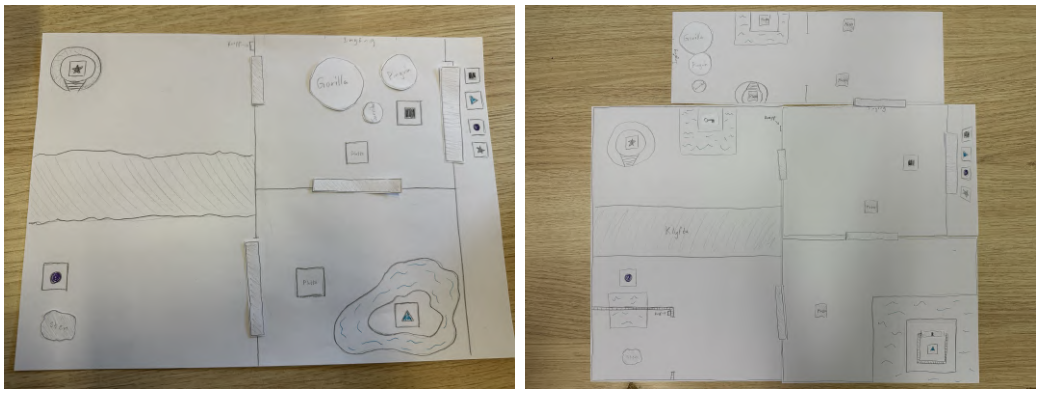

Figure 4.3: Prototypes from design iteration 1 and 2 for Level 2, from left to right

4.3.2 Prototype user testing

Due to the mechanics of the second level heavily relying on each player being an active participant in the puzzles, it has to reach a balance of not being too difficult to solve, yet also not being possible to solve too quickly. Therefore, it was decided that extensive play testing of this level prototype was necessary. Since the prototype is a top-down view of the entire level, the results from the prototype testing was mostly used for noticing if there were any major design problems or imbalance in the player roles.

An initial paper prototype was created (see Figure 4.3). It has four rooms, where each room has a pressure plate. The players have to help each other reach the different rooms, and the gorilla has to put a rock on one of the pressure plates to escape the level.

Three groups tested the level using cut circles representing the players. They were told to use the think-aloud method [30] during the testing, and answered some questions together afterwards. The first test showed the prototype to be too simple, with participants completing the level within a few minutes. The participants expressed the desire for more complexity, better feedback from object interaction, and for the penguin to have a more relevant role.

With the feedback, the level design was increased in complexity (see Figure 4.3). This time, the level has more rooms and more advanced puzzles that require collaboration. Two new groups, as well as one of the groups from before, tested the new paper prototype. The participants noted that the penguin had a less important role than the other two animals, as in the previous prototype, and that the complexity of the level could be further increased.

With that, a final version was created (see Figure 4.4), which was used as a guide for the implementation in Unity. This level increased the difficulty of the puzzles and features more puzzles and game mechanics from level 1, including a glass window that the gorilla has to break and more areas blocked by water, to further increase the importance of the penguin.

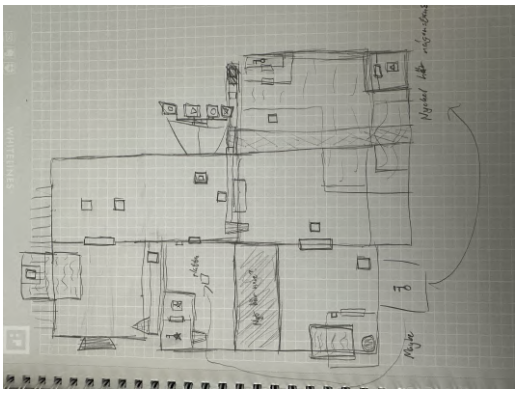

Figure 4.4: Final prototype for Level 2

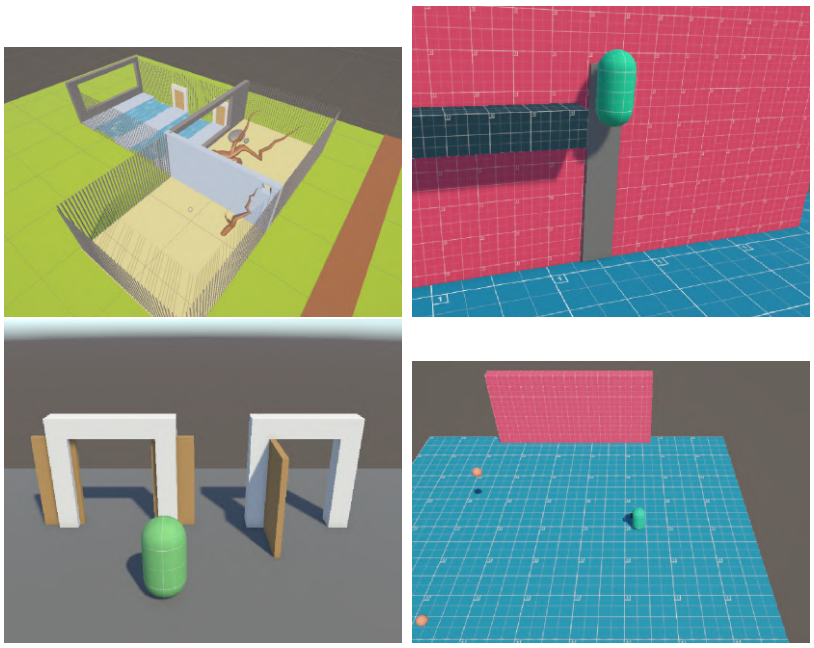

Figure 4.5: Some images of level 1 and the implemented features in sprint 1 and 2.

4.4 Game development

4.4.1 Game implementation

The work of implementing the game was divided among the team members. Each week, new tasks were assigned to each team member by using an agile workflow and a kanban board.

The first two sprints were dedicated to implementing different must-have features in the game (see Figure 4.5). Some of which were the player controls and their abilities: to jump and climb, as well as pick up and throw objects. Other features implemented were interactable doors with connected buttons and pressure plates, the NetCode synchronization to allow for multiplayer, and glass which can be broken by the gorilla throwing objects on it.

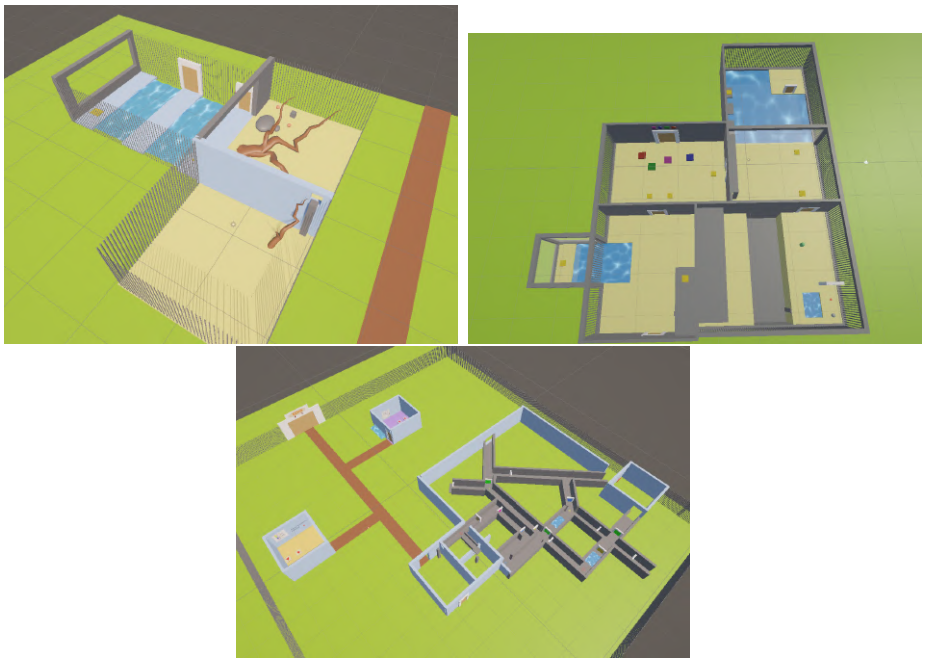

Figure 4.6: Some images of the implemented levels in sprint 3 and 4.

With the core must-have features implemented, the next two sprints were focused on adding levels to the game (see Figure 4.6). The levels were implemented by first implementing the general structure of the level with simple walls, floors, and the puzzles. Alongside this, the animal player avatars were implemented, as well as spawn points, which are used to set the coordinates the players start each level in. Further, the user interface was improved by adding visual icons for which buttons to press to use the abilities. The swim ability was fully implemented.

In the last sprints of the development process, the transitions between levels were implemented, as well as a starting screen where the connection between host and client players can be established. The visual aesthetics of the levels were improved by adding terrain, nature, and other animals in the enclosures (see Figure 4.7).

Across all sprints in the development cycle, team members would work on bugs that emerged. Often the assignment of bug fixes was divided so that the person who implemented the bugged feature was the one to fix it.

Some features were intended to be implemented, but were not due to time constraints or change of the intended player experience. Some of which were doors that require a key to open them and predators which can chase the players. The predators were aimed to increase tension in the game; however, it was decided that the game would have more focus on the puzzles and communication between players, which the predators may have interrupted if implemented.

4.4.2 Audio design

When creating the soundtrack, the aim was to make background music that was unobtrusive, pleasant, and reflected the game's aesthetic. The music being unob-

Figure 4.7: Some images of the improved levels and starting screen in sprint 5 and 6.

trusive is key to fitting well into the *background* by not interfering with the individual concentration of players, nor with the communication between them [45]. Making the music quieter when playing is the simplest way to achieve this, but there is more to it than that. If the music is too dissonant, beautiful or dramatic, it could be distracting for the players [46]. Moreover, it is beneficial to have uninterrupted looping, which means staying away from tempo changes and overly distinct starts and endings, ideally allowing the music to blend together seamlessly. On the other hand, if the music is too repetitive it becomes unpleasant.

To make the music pleasant, natural piano and trumpet sounds were used, alongside the more computer-like synths. The settings for the instruments were also edited to make the sound softer by having each note fade in slightly, decreasing the suddenness of each note. Further, the use of slow, syncopated melodies gave the music a light and fluid feel. In contrast, the faster basslines give the music a slightly more urgent undertone.

The game's aesthetic centers around the "zoo" and "prison break" concepts. The use of brass was, for example, supposed to allude to elephants trumpeting, and the beat is structured around percussive elements associated with a jungle theme such as bongos, congas, and a cowbell.

4.5 Assets

The animals added to the game are sourced from the **Low Poly Animated Animals** package in Unity Asset Store [47]. Environmental assets were also sourced from the unity asset store, specifically the **Low-Poly Simple Nature Pack** [48].

These assets enabled us to easily make the environment and player avatars recognizable, allowing us to focus on game functionality over asset design. The assets also assisted with giving the game a certain aesthetic and help communicate gameplay elements to the player. For instance, players quickly understood that the penguin character can traverse water. Overall, the use of assets helped with development and gameplay communication.

4.6 Playtesting

Playtesting was conducted to gather user feedback on the game, identify flaws, and analyze collaboration between players. Participants were recruited from Chalmers University of Technology, primarily from the departments of computer science, information technology, and global systems. Although many participants were initially recruited through the researchers' networks via convenience sampling, groups of three were deliberately configured so that players within the same group did not know each other. This was done to minimize potential bias in collaboration dynamics, since playing with friends has been shown to affect collaboration metrics [6].

When conducting the study, several ethical aspects were considered. According to the Chalmers BSc thesis regulations, the core principles are to do good, avoid harm, and respect others' integrity and autonomy [49, Appendix 7]. In alignment with the principle of respecting others' integrity and autonomy, participants were clearly informed about the purpose of the tests, and informed consent was obtained before any data was collected. Moreover, personal information was anonymized, and used only to improve the game and answer the research question.

Prior to the session, all participants signed a consent form. Each player was then assigned an individual computer with the game pre-loaded, each computer situated so the screen was only visible to the player using it. The available game characters were automatically assigned without any input from the subjects. Each player only played as their assigned character throughout the whole playtest. During the playthrough, participants were able to see and communicate with each other freely. To avoid influencing behavior, participants were not informed about the purpose of the study. After a brief explanation of the game's objective, escaping the zoo, the session started. The three levels were then played in order without any pause.

Throughout the gameplay, the researchers did not intervene unless players became stuck for an extended period of time due to missing critical information (e.g being unaware of a specific character ability). In order to minimize observer effects while also capturing sufficient data, three observers were present during each playthrough. Additionally, observers did not personally know the subjects whenever possible.

Following the playthrough, each participant was individually interviewed. The collected data was then used to evaluate how the game was perceived, which aspects of the design supported or hindered collaboration and communication, and how effective the interview questions were.

4.6.1 Playtest 1

The first playtest was conducted as part of the first iteration of the game development. The game was tested on two player groups, with both groups playing the same version of the game.

The playtest brought light to numerous problems with the game. Some of the most critical bugs discovered were the meerkats ability to walk through closed doors, and pressure plates not always activating doors.

The observations and feedback in the interviews gave insight in how the teamwork was throughout the game. For the most part, the collaboration worked well, except for the fact that the bugs affected the experience. One major flaw of the game was the level design of level 3. Here, it is crucial for the players to have effective communication, due to the *asymmetric information* pattern. However, the colors of the doors were difficult to differentiate, with players referring to the same door with different color names (for example confusing magenta with red). Alongside this, the penguin player reading the map confused the symbols on the map with the doors, causing further complication.

The players also expressed their opinions on the dynamic between the different animal characters. The players controlling the penguin found the character to be important, yet somewhat lackluster compared to the other characters. They expressed a desire for the penguin to have an additional ability, regardless of whether it was necessary for gameplay, simply to make the character more enjoyable to play. The players who controlled the meerkat felt it was the most important character of the three. They found it fun to be thrown and have an active role. The players playing as the gorilla found the character to be important, and enjoyed throwing the meerkat.

4.6.2 Improvements after playtest 1

With all this feedback in mind, a meeting was held to discuss what problems there were with the game that needed to be fixed. Primarily, the game-breaking bugs had to be handled as soon as possible. Also, the penguin character needed some rework since it did not feel as engaging as the other characters.

It was decided to give the penguin its so-called “bouncy-mode” ability. This is an ability used together with the meerkat. It allows the penguin to become wide, enabling the meerkat to jump on the penguin to reach higher areas. Since it only launches the meerkat vertically, it does not diminish the gorilla’s throw-ability, which launches the meerkat mainly horizontally. The ability increases the importance of the penguin player and increases interdependence between the penguin and the meerkat.

The third level went through a major redesign. The colors of the doors were reselected to have enough contrast to not be confused with each other. The maze was increased in size, and the landmarks inside the maze were changed from symbols in the floor to animal enclosures on the ground, to ease coordination between the map reader and the meerkat. Additionally, the pressure plates used for opening the

doors in the maze were connected to lights, which light up when the pressure plates are activated, to give a clearer indication of whether they are pressed or not.

In addition to this, two new design options for the third level were explored. Two versions of the level were created, where each would be tested in the next playtest. The first version let the gorilla and penguin switch places in the middle of the meerkat solving the maze. This was done since the gorilla was observed as having less to do in the third level compared to the other players. The second version added three buttons throughout the maze which the meerkat is required to press. The buttons are marked on the map, so the penguin has to guide the meerkat. This is intended to make the maze more complicated, and therefore increase the importance of the penguin reading the map. In addition to this, once a button is pressed, a light is activated in the map room to give visual feedback to the penguin about the meerkat's whereabouts.

All the levels were visually improved by adding scenery, intended to increase immersion in the game. The interview questions were also updated to be more specific and give examples to get more elaborate answers from the next playtest (see Appendix A.1). This was done to cover some blind spots that were noted from the first set of answers received.

4.6.3 Playtest 2

The second playtest was conducted as part of the second iteration of the game development. The game was tested on four player groups, with two groups playing a separate version of level 3, to see what effects the design choices of that level had on collaboration metrics. Since this playtest used the final version of the game, the results from this playtest were only used for answering the research question, not improving the game.

4.7 Thematic analysis

After the playtests, an iterative process of thematic analysis of the observations and interview answers were conducted. In the first step the notes were summarized. Then patterns or themes connected to communication and collaboration were identified. These identified themes are described in Table 5.4, and were later used to analyze the data from the different levels and groups. The result section shows what collaborative and communicational themes were observed and reported for each group and level, as well as a further analysis of the communicational and collaborative themes of the different game design patterns identified in the game. The communicational and collaborative actions were video recorded together with the state of the game-play, which allowed the connection between game design patterns and the themes.

The thematic analysis was conducted at different levels. The data set was chosen based on the topic, i.e. collaboration or communication. In the first step the data was separately analyzed for each group and level. For the interview answers the

data set was only divided by levels and not by groups, and for the final analysis game design patterns were identified in the whole data corpus and the themes for each pattern was summarized from every occurrence of the game pattern.

5

Results

5.1 ZooBreak – the game

5.1.1 Level 1: tutorial level, asymmetric roles

The first level focuses on the *asymmetric roles* pattern. It introduces the players to their character's abilities, as well as the mechanics and controls of the game. An overview of the complete level is shown in Figure 5.1. In Figure 5.2 the starting screens for the different players are shown. The players are separated at the start of the game, and to escape the level, the players have to use their different abilities. The meerkat has to use its climbing and jumping ability to get over to the gorilla's cage, and the gorilla has to throw a rock to break the glass to the penguin cage. The main puzzle of the level is in the penguin cage (Figure 5.3). The goal is to go through the doors to the next room. This requires all three players to use their abilities and get to different positions as seen in Figure 5.3.

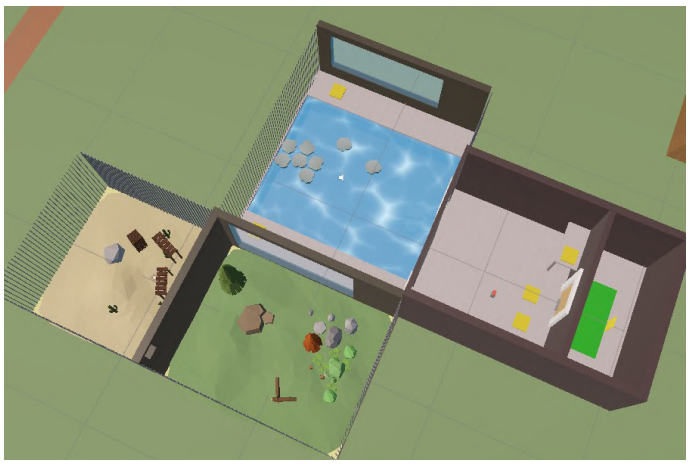

Figure 5.1: Final map design for Level 1.

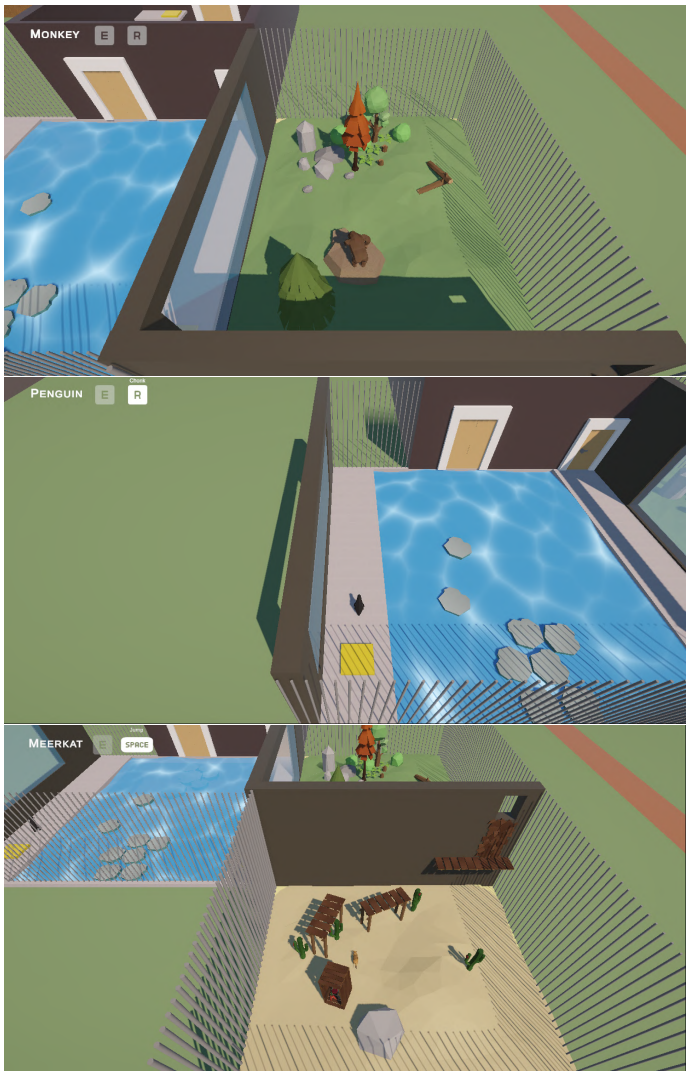

Figure 5.2: Initial views for the different players in level 1. From top to bottom: gorilla cage, penguin cage, and meerkat cage.

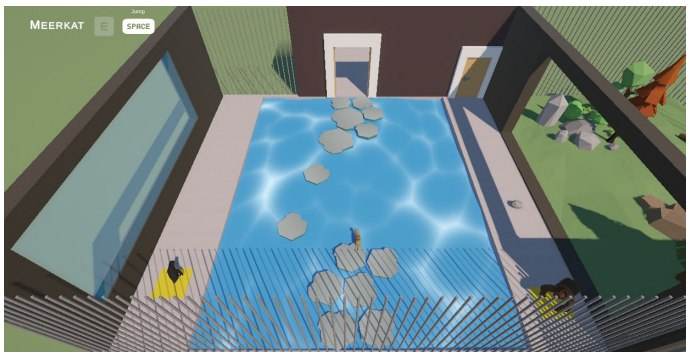

Figure 5.3: The shared puzzle/obstacle in level 1.

Figure 5.4: The end of level 1.

The collaborative game design patterns identified in this level are:

- *Shared goals*: opening the doors and escaping the cage.
- *Asymmetric roles*: the players' different abilities are all required to reach the shared goal. The penguin must swim, the gorilla must break the glass, and the meerkat must do parkour to pass the water. Additionally, the gorilla throws the meerkat across the water, and in the last room the meerkat must jump on the penguin to reach its pressure plate.
- *Concurrency*: the left door in the penguin cage is operated (opened) by both the penguin and gorilla standing on pressure plates simultaneously.
- *Shared puzzles*: opening the door to the right in the penguin cage by getting the meerkat across the water and through the left door.
- *Asymmetric information*: in the beginning, when the players are in separate game locations they have different knowledge, and each player only get presented with their own abilities (as shown in Figure 5.5), not others'.
- *Gathering gate*: at the end of the level (as shown in Figure 5.4) all three players are needed to press down three pressure plates simultaneously to open the final door (to the next level).

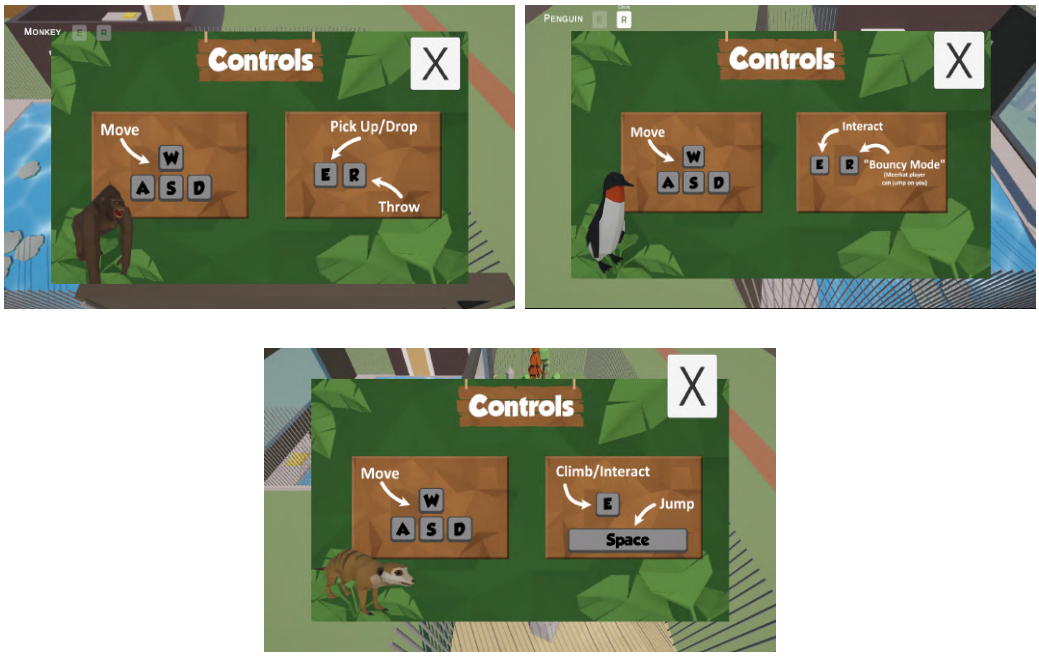

Figure 5.5: Control views for the players.

5.1.2 Level 2: concurrency level

The map design of the second level can be seen in Figure 5.6. The starting location is at the top left in the figure and the end location in the top right. In order to open the last door, and finish the level, the players must press four differently colored pressure plates in different locations simultaneously. The level aims to encourage player collaboration by introducing *concurrency*. This is implemented through pressure plates and doors that is operated concurrently by several players, as shown in Figure 5.7. The collaborative design patterns identified in this level are the following:

- *Shared goals*: to light up all the symbols above the last door (seen in Figure 5.9), open it and continue to next level.
- *Asymmetric roles*: for the penguin, water to swim across, for the gorilla, stones to put on pressure plates and glass to break, and for the meerkat, climbing (as shown in Figures 5.8).
- *Concurrency*: opening doors together.
- *Shared puzzles*: getting to the different rooms and getting past shared obstacles.
- *Separation gates*: one player being separated from the group, as a result of keeping a door open for the others.

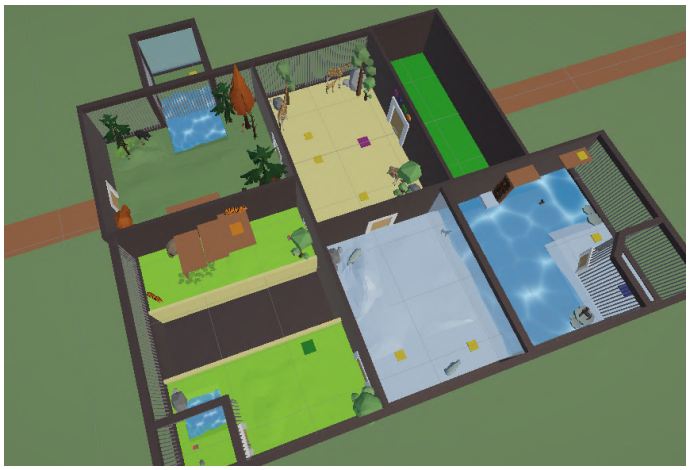

Figure 5.6: Final map design for Level 2

Figure 5.7: Example of concurrency, the gorilla and meerkat opening a door together.

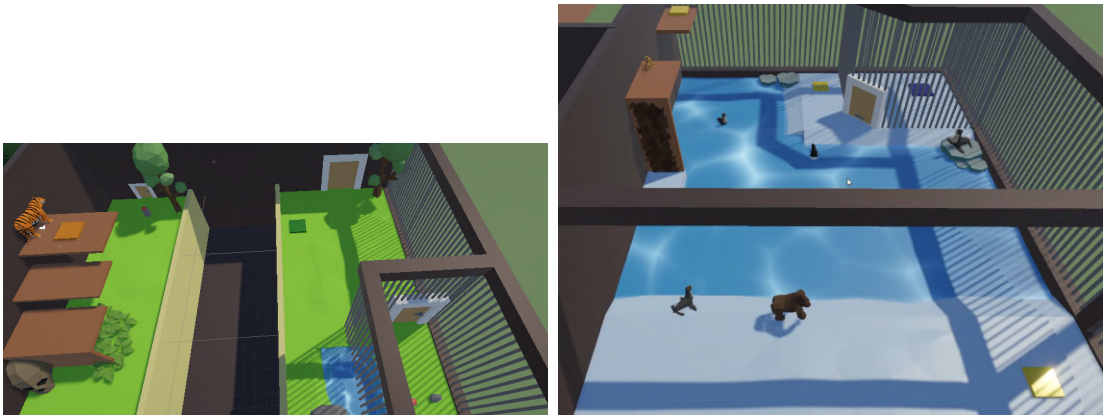

Figure 5.8: Two of the rooms in level 2 which center around asymmetric roles and a shared puzzle.

Figure 5.9: The end of level 2.

5.1.3 Level 3: asymmetric information level

The third and final level introduces the players to the *asymmetric information* pattern, where each player has access to different information. The level has two versions (see Figure 5.10 and 5.11), where both versions feature a maze that leads to a button to open the main exit of the zoo. The level separates the players so that only the meerkat travels through the maze (as seen in Figure 5.13), the penguin can go to a room with a map of the maze (Figure 5.12), and the gorilla has to go to the control room (Figure 5.14) to open doors in the maze.

The difference between version one and version two is that in version one, the gorilla and penguin have to switch places in the middle of the level. In version two, there are three buttons in the maze for the meerkat to press (as seen in the bottom part of Figure 5.13), and this will make lights light up on the map (as seen in the right of Figure 5.12). The collaborative design patterns identified in this level are the following:

- *Shared goals*: getting the meerkat through the maze, opening the last door and escaping the zoo.
- *Concurrency*: doors requiring both the gorilla and penguin to stand on a pressure plate simultaneously.
- *Shared puzzles*: opening doors and getting the meerkat through the maze.
- *Asymmetric information*: the players have different information, with the meerkat seeing the maze, the penguin seeing the map over the maze, and the gorilla seeing what doors the pressure plates open.
- *Separation gate*: only the meerkat being able to go into the maze, only the penguin being able to go to the map room, and the gorilla having to go to the control room.

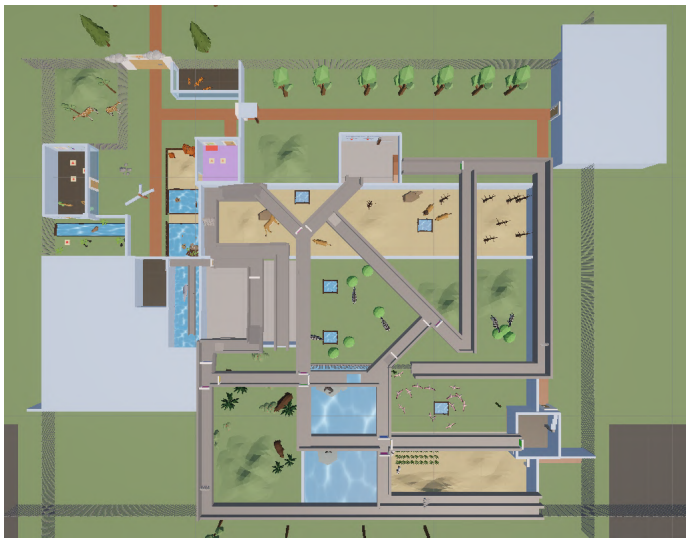

Figure 5.10: Map design of Level 3, version 1.

Figure 5.11: Map design of Level 3, version 2.

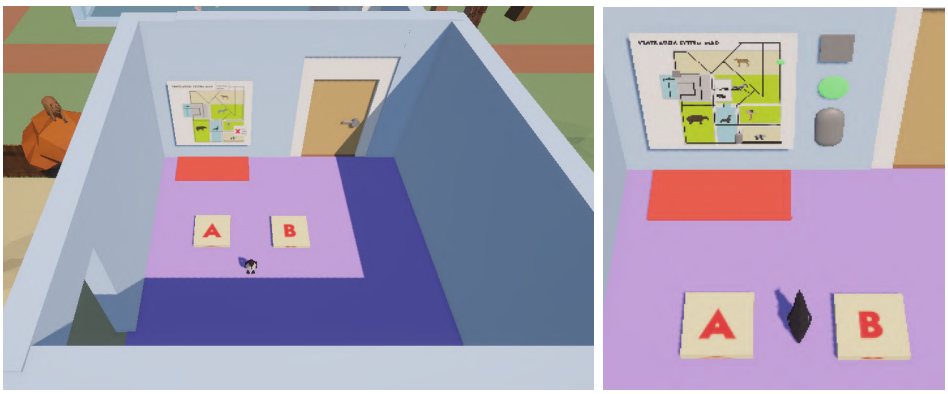

Figure 5.12: The maproom in Level 3, with version 1 to the left, and version 2 to the right.

Figure 5.13: The maze in Level 3, with version 1 on the top, and an example of the buttons in the maze in version 2 on the bottom.

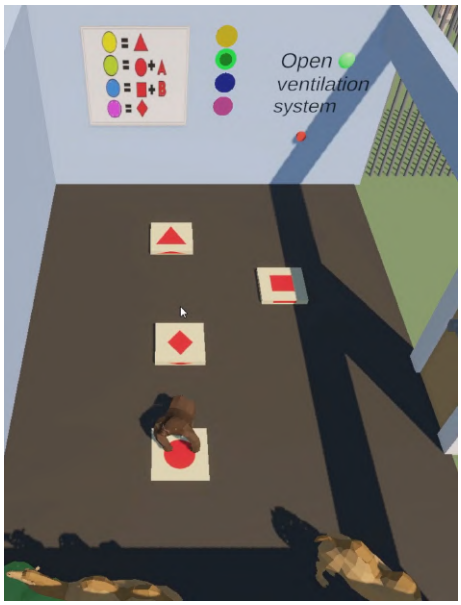

Figure 5.14: The control room in Level 3

5.2 Playtest 1

The results of communication and collaboration themes during the first test are summarized using *thematic analysis* in Table 5.1, Table 5.2 and Table 5.3, the first

Table 5.1: Thematic analysis of observations of communication during playtest 1.

	Level 1	**Level 2**	**Level 3**
Communication			
All	Knowledge sharing		Coordinating Knowledge sharing Strategizing
G1	Inattentive conversations	Knowledge sharing Understanding game mechanics together	Understanding game mechanics together
G2	Coordinating Strategizing	Coordinating Strategizing	

Table 5.2: Thematic analysis of observations of collaboration during playtest 1.

	Level 1	**Level 2**	**Level 3**
Collaboration			
All		Assisting	
G1	Group disengagement Individual play	Individual play	Assisting Individual play
G2	Assisting Common problem solving	Common problem solving	Common problem solving

table based on the observation notes and the second one from the interviews (the themes described in Table 5.4). The groups displayed some similarities in the themes, but also a lot of variation in the way they solved the game and the collaboration and communication themes that arose. The game was slightly buggy, which allowed the players to cheat by, for example, phasing through doors. This impacted how the game was played and what communication and collaboration was needed to complete some puzzles. The following sections will describe the results of the observations and interviews for each level.

5.2.1 Level 1

In the first level, the groups exhibit different collaborative and communicational themes. Group 1 (G1) exhibited outloud monologues while exploring the game mechanics and the collaboration was minimal for this group, with mainly individual work.

Table 5.3: Thematic analysis of player interviews in relation to collaboration in different levels in playtest 1.

	Level 1	**Level 2**	**Level 3**
G1	Individual play Unbalanced collaboration	Balanced collaboration	Asssisting Unbalanced collaboration
G2	Balanced collaboration Individual play	Balanced collaboration	Assisting Common problem solving Group disengagement

Group 2 (G2) displayed more varied communication. They had difficulty solving the main puzzle, and showed some frustration. However, the communication became more elaborate due to the perceived difficulty. They solved the level in an unexpected way, by placing rocks which the meerkat could jump on across the water, thus skipping the intended solution.

5.2.2 Level 2

G1 discussed game mechanics (buttons, doors, and colors of pressure plates), as well as sharing knowledge about confusing parts of the level. Their collaboration was limited to helping each other by opening doors, but lacked any overall shared strategy. G2, on the other hand, communicated both about the game mechanics and formed common strategies. They collaborated by helping each other opening doors and had a shared plan on which they executed.

Both groups displayed moments of waiting for each other. For group 2, the meerkat had trouble jumping and repeatedly fell into the water in one of the puzzles. During this period, the players exhibited signs of frustration and subsequently reported a decline in mood caused by them having to wait on the meerkat. Similarly, the meerkat displayed frustration due to the pressure of forcing the other players to wait. The doors that implement the *separation gate* pattern also forced players to wait. During the time that a player was waiting, communication from that player was limited.

5.2.3 Level 3

G1 displayed various types of communication. They shared knowledge about their respective views, discussed the meaning of symbols, and coordinated their efforts to open the doors in the maze. For the collaboration in this level, the gorilla and penguin coordinated their actions to open doors for the meerkat. They did not use the map to navigate the maze, but instead the meerkat navigated the maze alone via trial-and-error.

G2 displayed knowledge sharing, strategizing, and coordination. However, due to some oversight in the level design, some aspects of the level were difficult to decipher and communicate about. For example, the symbols on the map had different colors, and the doors also had similar colors. As a result, when the meerkat referred to a door color, the penguin thought it referred to a symbol color, which caused confusion. The collaboration displayed in this group was to navigating the maze together, using the map and pressure plates. Also, during their moment of confusion about the doors and symbols, they started showing their computer screens to each other.

5.3 Playtest 2

The second playtest had a more refined version of the game and twice as many groups (i.e. four), compared to the first playtest. During this playtest, the game had two different versions of level 3, as described in section 5.1.3. Version one

was played by group 1 (G1) and group 3 (G3), while version two was played by group 2 (G2) and group 4 (G4). Although minor bugs occurred during gameplay, it did not significantly alter progression or enable unintended solutions, unlike in the first playtest. The playtest observations and conclusions from the interviews are described below for each level and group, which is followed by the resulting thematic analysis (in Tables 5.5, 5.6 and 5.7).

5.3.1 Level 1

All four groups displayed similar collaborative behaviors in level 1. They all communicated with each other in the beginning, either about their abilities, what animal they controlled, or their surrounding environment. Each group discussed strategy on how to solve the puzzle in some way. Common within all groups was some confusion with one of the three playable characters' abilities, either forgetting abilities or finding the abilities buggy at times.

G1 approached the level with coordination and problem solving. The players applied their abilities to the puzzle, such as using the gorilla to place stones on pressure plates. The group frequently interacted in playful ways, suggesting a relaxed and socially engaged atmosphere.

For G2 the solution to the puzzle was identified by one of the players, who then reported this to the rest of the group. This allowed them to focus on mechanics of the puzzle since they already knew what to do. The level was solved in an unexpected way by combining the penguin's "bouncy mode" ability and the meerkat's parkour ability.

For G3, the participants had lower average gaming experience and they struggled noticeably more than the other groups. The group needed more time to understand the abilities of the characters, where the gorilla player in particular struggled to remember their abilities. This appeared to increase the amount of assistance and communication within the group, as they relied more heavily on each other to progress. With a fairly slow pace, they eventually completed the level.

G4 spent a long time understanding each others' abilities before attempting the actual puzzle. They communicated and encouraged each other to physically show their abilities in the game, so that everyone would have a better understanding of what abilities and interactions were available to them. G4 struggled with finding the solution to the level, but once they completed the level, they reacted with excitement and satisfaction.

5.3.2 Level 2

All four groups displayed clearer communication and more coordination during level 2 compared to the first level. The groups generally spent less time learning mechanics and more time focusing on the main puzzle of the level. The separation of players into different rooms created asymmetric information, requiring players to rely on verbal communication. The level was more complex than the previous and the communication also involved more strategic planning.

G1 began by exploring the environment and discussing their options on how to progress. Some mechanics from the previous level had been forgotten, such as breaking glass by throwing rocks. Players displayed some individual play and inattentive conversation by several players verbalizing individual reasoning and problem solving simultaneously. However, they also discussed in the group for example, what the different pressure plates did. The group had a good understanding of their abilities, allowing them to interact and focus on problem solving. Throughout the level, the participants assisted each other by sharing observations from separate rooms and suggesting ideas.

G2 were quick to understand the level's main objective and mechanics, and the penguin player managed to put it all together quickly. The group showed effective communication and helped each other by informing everyone of what they found in different rooms. This allowed them to connect solutions to different sections of the map. At certain moments, either the penguin or the gorilla would have low active involvement, because they would either need to stand idle on a pressure plate, or just wait for the others to solve a puzzle together.

G3 progressed through the level at a slower pace than the other groups. The group spent considerable time exploring the different rooms and attempting to understand how the different puzzle areas connected together. At times lack of communication delayed game advancements, particularly when the gorilla player failed to inform the group about an important area containing water for the penguin to use and unlock access to a rock. Once the penguin discovered the area with the rock, the group began coordinating more efficiently and strategized on how to solve the remaining part of the level. Although the group was less efficient than the others, they were engaged with each other at all times and communicated by sharing ideas, organizing player positions and what pressure plates to activate.

G4 understood what to do rather quickly. Since the group already had a solid understanding of their abilities, they were able to focus primarily on the level and its mechanics. They started strategizing early and discussed player positions to advance the level. The group maintained involvement among everyone by updating each other about events when working in different rooms or waiting on others. During the middle of the game, the gorilla soft locked itself in a room, forcing a restart of the level. This did not seem to negatively impact the mood of the group, as they quickly and smoothly returned to their original point of progress. The group also encouraged everyone throughout the level with words, retaining a positive atmosphere. Towards the end when everyone needed to position themselves in order to advance to the next level, the meerkat player took a leading role together with the penguin player in discussing a strategy.

5.3.3 Level 3

All four groups began by exploring the level and sharing what information they observed. A recurring pattern was that collaboration between the penguin and meerkat players became central to progression, particularly when communication about landmarks and positioning within the maze was effective. The gorilla was

observed to be less involved in communication and expressed some boredom in both versions of the game, with these effects being more pronounced in Version 2. Groups that established clear communication and shared understanding early on progressed more efficiently and completed the level faster, whilst lack of coordination led to slower progression and more individualistic play.

G1 played version 1 of the level. In this group, there was initially som confusion about the goal and puzzle of the level. After understanding the goal, the meerkat solved the maze mostly individually with only minor communication with the others. The gorilla discovered a method of placing rocks on the pressure plates which reduced the need for communication with the rest of the group. The penguin attempted to assist the meerkat by providing guidance, but the meerkat's rapid pace through the maze made it difficult to pinpoint its position. As a result, much of the progression came from individual actions, rather than collaboration. However, at the point of switching positions, all three were active in the discussion and sharing knowledge about what happened for them. In contrast to the groups playing version 2 of the level, the penguin in this group reported feeling less important and disengaged than the gorilla.

G2 played version 2 of the level. The group initially positioned themselves in the correct areas of the level, but all members soon moved to the control room (Figure 5.14). After receiving a hint from the researchers that the meerkat should be in the maze, G2 began knowledge sharing and progressed through the maze. The gorilla's play style was similar to the previous group, G1, however the collaboration between the meerkat and penguin was more effective in G2 than in G1. Effective collaboration between the meerkat and penguin only began after the meerkat discovered the first button within the maze. This allowed the penguin to determine the meerkat's location and effectively guide the meerkat through the remainder of the maze.

G3 played version 1 of the level and had noticeably lower experience with games in relative to any other group. They took more time to understand the level and initially struggled to make any progress. At a certain point, a brief intervention from the observing researchers was made to clarify some areas of the level. From thereon, the group communicated and interacted with each other thoroughly. Both the gorilla and the penguin had an important role guiding the meerkat through the maze, making the collaboration relatively balanced.

G4 played version 2 of the level. The group initially displayed some confusion, for example, with the meerkat hesitating to enter the maze. After collectively understanding the objective, the penguin and meerkat demonstrated strong communication and collaboration. In contrast to groups G1 and G2, the gorilla was less engaged in G4 due to the repetitive nature of the pressure plates. Overall, the group maintained a swift pace, completing the level faster than any other group.

5.3.4 Thematic analysis

The communicational and collaborative themes displayed by the different groups at playtest 2 are described in table 5.5, 5.6, and 5.7 (the themes are defined in table

5.4). General communication themes throughout the game were knowledge sharing, understanding game mechanics together, strategizing, and coordinating. The first three were more prevalent in the earlier stages of the game, while coordination became more prominent later on. The main collaborative themes throughout the game were common problem solving and assisting. However, uneven contribution and unbalanced collaboration were also observed several times across different groups and levels. The observed themes in both versions of level 3 were similar, with the main difference being that strategizing themes were only identified in the interviews from players who played the second version of level 3. Furthermore, table 5.7 shows that the players' perceived and reported communicational themes agrees with the researchers observations. The collaboration themes indicates that the first level was perceived more balanced while level 3 was the most uneven by the participants. However this distinction was not clear from any observational notes.

Table 5.8 shows what game design patterns were identified in relation to different communicational and collaborative themes. It shows that players being separated in the game, as opposed to being at the same location, can result in less engagement in other players' actions. The occasions where players were in the same area resulted in players displaying higher social behaviors, such as laughing, casual talk, and encouragements. However, *asymmetric information*, which was mainly implemented by separating the players, resulted in diverse communication and common problem solving. The *shared goals* also resulted in common problem solving as well as teamplay by strategizing and encouragement. *Shared obstacles* and *concurrency* resulted in players communicating in order to coordinate and assist each other. Although *shared puzzles* resulted in players coordinating and strategizing, puzzle-solving varied between individual and collaborative approaches across different groups. *Asymmetric roles* resulted in knowledge sharing, and affected the collaboration and workload between players to be balanced or unbalanced in different levels.

Table 5.4: Thematic analysis: patterns and definitions for communication and collaboration.

Pattern / Theme	**Definition**
Communication	
Understanding game mechanics together	Players discussing how elements in the game work (e.g., buttons, doors, symbols)
Knowledge sharing	Players sharing information with each other, explaining things others do not know or cannot see
Coordinating	Communication during execution of simultaneous tasks, telling each other to perform actions
Requesting assistance	Players asking others for help
Offering assistance	Players offering help to others
Inattentive conversation	Players communicating about different things simultaneously or having outloud monologs
Strategizing	Planning together how to solve puzzles or reach the end of a level
Having fun together	Laughing or talking casually about things beyond the game goal
Encouragement	Players encouraging each other verbally
Collaboration	
Group engagement	Players being interested in and aware of what others are doing
Group disengagement	Players not being interested in or aware of others' actions
Individual play	Players exploring the environment or working alone, e.g solving a task alone without discussion
Interactions	Players interacting with others (where it is not required)
Assisting	One player helping another
Common problem solving	Solving a task or puzzle together
Balanced work	Everyone has equal amounts to do
Uneven contribution	One or more players waiting for others to finish tasks
Balanced collaboration	All players collaborate equally
Unbalanced collaboration	Only some players collaborate, or collaboration is hierarchical

Table 5.5: Thematic analysis of communication of the game-play observations of playtest 2.

Communication			
Group	**Level 1**	**Level 2**	**Level 3**
All		Knowledge sharing Strategizing	Knowledge sharing
G1, V1	Encouragement Having fun together Knowledge sharing Strategizing Understanding game mechanics together	Coordinating Encouragement Inattentive conversation Requesting assistance Understanding game mechanics together	Inattentive conversation
G2, V2	Inattentive conversations Understanding game mechanics together	Offering assistance Requesting assistance	Coordinating Having fun together Requesting assistance Understanding game mechanics together
G3, V1	Having fun together Offering assistance	Having fun together Understanding game mechanics together	Coordinating Having fun together
G4, V2	Encouragement Offering assistance Strategizing Understanding game mechanics together	Coordinating Encouragement Having fun together Inattentive conversations	Coordinating Offering assistance Requesting assistance

Table 5.6: Thematic analysis of collaboration of the game-play observations of playtest 2.

Group	**Level 1**	**Level 2**	**Level 3**
Collaboration			
All			Individual play
G1, V1	Assisting Group Engagement Uneven contribution	Group Engagement Individual play Interactions	Uneven contribution
G2, V2	Uneven contribution	Common problem solving	Assisting Intercations Unbalanced collaboration
G3, V1	Assisting Common problem solving Group engagement	Common problem solving Individual play Unbalanced collaboration Uneven contribution	Assisting Balanced collaboration
G4, V2	Common problem solving Uneven contribution	Common problem solving Group engagement Individual play Unbalanced collaboration	Assisting Common problem solving

Table 5.7: Thematic analysis of communication and collaboration of the interviews for playtest 2.

Communication			
Level 1	**Level 2**	**Level 3, v1**	**Level 3, v2**
Knowledge sharing Strategizing	Coordinating Strategizing	Coordinating	Coordinating Strategizing
Collaboration			
Level 1	**Level 2**	**Level 3, v1**	**Level 3, v2**
Balanced collaboration Even contribution Individual play	Assisting Common problem solving Group Disengagement	Unequal collaboration Uneven contribution	Unequal collaboration Uneven contribution

Table 5.8: Identified patterns and resulting themes for communication and collaboration.

Game Patterns	**Communication Themes**	**Collaboration Themes**
Separation gate/separate game locations	Inattentive conversation Knowledge sharing	(Risk of) Uneven contribution Group disengagement Individual play
Same location/gathering gate	Encouragement Having fun together Knowledge sharing Requesting and offering assistance	Balanced collaboration Group engagement
Shared obstacles/ Concurrency	Coordinating	Assisting
Shared puzzles	Coordinating Strategizing	Varying from individual play to common problem solving
Asymmetric roles	Knowledge sharing	Assisting Individual play Varying from balanced to unbalanced collaboration Varying from balanced work to uneven contribution
Shared game elements	Understanding game elements together, coordinating	Assisting
Asymmetric information	Coordinating Knowledge sharing Understanding game mechanics together	Common problem solving Individual play Varying from balanced to unbalanced collaboration Varying from balanced work to uneven contribution
Shared goals	Encouragement Strategizing	Common problem solving
Interactions	Encouragement Having fun together	Group Engagement

6

Discussion

This chapter discusses the results from playtests 1 and 2, implementations of different game design patterns for three-player games, extensibility, and sources of error.

6.1 Results from playtest 1

The first playtest shows that the same game can be experienced and played differently by different groups of players. This was evident from the difference in communicative and collaborative themes between the two groups, as seen in table 5.1 and table 5.2. G1 had clear themes of *Individual play* throughout the playtest, as shown in table 5.3. Surprisingly, G1 completed the game faster than G2, despite seemingly communicating and collaborating less. This indicates a possibility that the game was easier to complete with less collaboration between players. This was not intended, but likely a side-effect of the game not being fully polished yet and therefore letting the players bypass some challenges, for example by the meerkat phasing through some walls.

The lack of refinement also caused frustration for G2. By playing the intended way some game sections seemingly became too difficult and unintuitive, thus inhibiting collaboration by causing frustration. Specifically, in level 3, the different meanings of colors and symbols confused players instead of helping them solve the task. Thus, it was slower and more difficult to solve the puzzle together than to use trial-and-error. A key takeaway for future game development is the importance of clear and consistent designs in collaborative games, and especially when implementing *asymmetric information*. Another takeaway is that game difficulty should come from puzzles rather than unclear mechanics. This was illustrated in the second level, where both groups engaged in discussions about possible solutions and collaborated by assisting one another. Since no new mechanics were introduced in this level the difficulty instead emerged from the layout and required task sequence.

6.2 Results from playtest 2

Differences in the results from playtest 1 to 2 are for example that players displayed less frustration and more encouragement, and having fun together. This further strengthens the hypothesis of the unrefined game mechanics and confusing game elements causing frustration, and decreasing positive group communication such

as encouragement and laughing together. Additionally, in the second playtest the interdependence and interactions between players' characters were increased, for example by adding the penguin's "bouncy mode" and slightly redesigning the levels to require its use. This suggests that character interactions can enhance the mood in the group, which in turn can strengthen the sense of teamwork. The takeaway that clear game mechanics are particularly important for collaborative games were further strengthened by observations from playtest 2, where a majority of the groups used the map in level 3 to guide the meerkat through the maze as intended. In contrast to playtest 1, this approach proved effective in solving the level. This was likely due to the map containing more intuitive landmarks, as well as the increased cost of going the wrong direction caused by the increased size of the maze.

As previously mentioned, the third level had two different versions for playtest 2. When comparing the results of the two versions, it suggests that in version 1 the gorilla felt more engaged and collaboration became more balanced, caused by the gorilla and penguin switching places. Further, this indicates that stationary tasks leads to more disengagement or boredome, especially in the task is too simple. However, for the second version (with buttons in the maze), the number of communication themes was higher. This suggests that the visual feedback the penguin receives from the meerkat pressing buttons in the maze had a positive impact on collaborative communication. It further indicates that providing feedback about players' actions can enhance collaboration by improving common understanding and thus making communication easier.

The playtest also revealed difficulties in engaging three players simultaneously throughout a collaborative game, especially when using *asymmetric information* and *separation gates*. This was for example demonstrated in level 2, where occasionally one player was left behind to hold open a door and just had to wait, as well as throughout level 3. To solve this problem it could be considered to let the idle player solve a separate task on their own. Although this would not increase collaboration, it would act as downtime mitigation, keeping the player engaged while the others solve a section. Another solution is to make sure every player has enough complexity in their tasks. Particularly in level 3 of the game, the complexity of the tasks proved to be unbalanced, with the gorillas task being rather simple, but the meerkat and penguin's task considerably more complex, which seemingly caused the boredom and disengagement of the gorilla.

Most participants in the playtests had some degree of gaming experience. However, one group (G3) had a considerably lower average level of gaming experience compared to the others, and took far longer to complete the game. Unlike the other groups, they progressed through all levels closely to how the designs were intended, which in turn led to an interesting conclusion. Players with considerable gaming experience may require levels with a higher degree of complexity to accomplish purposeful collaboration, whereas players with a lower gaming experience may require the opposite.

6.3 Design patterns for three-player games

In this section, patterns that worked well and patterns that were less suitable for a collaborative three-player game in the way they were implemented will be discussed. We will discuss how the patterns that worked well support collaboration and communication, what problems or improvements the patterns that worked less well would need, and what to consider to adapt the patterns to three players. Since the implementation of the game design patterns has a major effect on their effectiveness in encouraging collaboration, the evaluation of the patterns will focuses on strengths and weaknesses, as well as pitfalls when implementing them.

6.3.1 Pattern implementations with positive outcomes

Shared goals is a central design pattern for collaboration and has to be present for there to be a collaborative game. The *team play* pattern is also always present as a result of the players having a shared goal. The *shared goals* and *team play* patterns work well when players have a clear motivation to collaborate. In our case, the shared goal was to escape from a zoo, and the players being a team of animals fleeing together generated enough motivation to keep progressing in the game. The *shared goals* pattern was shown to cause only positive themes, such as strategizing and common problem solving, as shown in table 5.8.

For a three player game, the *asymmetric roles* pattern seems to work well. This is evident by the interview answers, since each player stated that their role and contributions felt important. Even though players at times had nothing to do, their particular abilities were always needed at some point in order to complete the level and this seemed to make all players feel important even though they were not always contributing. For collaboration to occur it is especially important to engage all players, and with three players, giving them *asymmetric abilities* and creating interdependence in that way seems to do this effectively.

Concurrency was effective in encouraging players to communicate and coordinate their actions, as shown in table 5.8. As implemented in Level 2, it prompted players to discuss which pressure plates they were standing on in the different rooms. Furthermore, it encouraged players to explain the mechanics of the pressure plates to one another, as the game itself provided no explicit instructions.

The implementation of the *shared puzzles* pattern was shown to be appropriate for three players. Similarly to *concurrency*, the *shared puzzles* encourages players to communicate and discuss possible solutions, as shown in Table 5.8. The most effective implementations of shared puzzles were shown to be puzzles where specifically three players were needed. This made sure all players had a part to play, and that each player was a part of the discussions.

6.3.2 Pattern implementations with negative side effects

The *separation gates* pattern was not particularly successful in its implementation in this project, especially in Levels 2 and 3. A central issue was that the pattern

often resulted in one player being left isolated and idle while the others continued interacting. This was particularly evident in Level 2, where one player was forced to stay behind while the other two progressed to the next room. The two advancing players primarily interacted with each other, leaving the third player excluded from the collaboration. These observations suggest that separation gates should either avoid isolating a single player, or divide all players into separate areas, as was done more successfully in Level 3. An additional observation was that the pattern at times appeared to cause hesitation among players, particularly in Level 3 where players were seen approaching the maze before quickly returning, seemingly due to reluctance to separate from the group.

The implementation of *gathering gates* caused players to wait for each other, which caused frustrating time delay for the players waiting. Since the existence of *gathering gates* relies on the existence of *separation gates*, they both seem to exhibit the same negative side effects when used together.

The *asymmetric information* pattern was shown to be tricky to implement, which is why it should be used with caution. The pattern was effective at encouraging communication between the players, but only when the information provided to each player was understood, and they knew how to connect all the information into a full picture. Across the playtests, when information was not understood by one part, the other players tried to solve the problem as a pair, rather than waiting for the player to understand. Therefore, the collaboration became unbalanced, as seen in Table 5.8. On the other hand, the information provided to each player should also be complex enough so their information is needed and engaging. The gorilla in level 3 exhibited disengagement while pressing pressure plates, due to the simplicity of the task. It only required the gorilla to say a shape to the other players, while the meerkat and penguin could engage in more complex communication about where they are and should go. Thus, the pattern was less effective than intended at engaging all three players, the way it was implemented in the game.

6.4 Extensibility and further development

The game offers a high degree of extensibility, allowing additional levels with different designs and puzzles to be added in the future. It is also possible to give the player characters more synergy between each other, by allowing more interactions between them, similarly to how the gorilla can throw the meerkat. Due to the extensibility of the artifact itself, the study can be performed with more metrics or collaborative design patterns to further explore the possibilities and limitations of creating a three-player collaborative game. One possibility is to recruit more participants to get more quantitative results. It is also worth mentioning the puzzle aspect could be extended by including more animals with unique abilities and allowing the players to figure out what combination of three animals is correct for solving a level.

6.5 Sources of error

Evaluating game design patterns can be difficult and somewhat unreliable. The effect a pattern has on the player depends on a multitude of factors, such as how the pattern was implemented, how invested the player is in the game, and the players personal preference. This makes it almost impossible to accurately measure the effect of the pattern used [17, p. 35]. For example, the collaborative pattern of *asymmetric roles* can be implemented by assigning abilities to players. There are several factors, not all under experimental control, that can affect the user experience; how abilities are introduced, how they complement each other, and how they interact with the game environment. As a result, the true differences between our tested collaborative design patterns may be hidden due to variations of the players' experiences.

In the first playtest, the game was shown to be riddled with bugs that had not yet been discovered. Due to this, the evaluation of the collaboration for the first playtest was affected by the game not working as intended. For example, because the meerkat could run through doors, it could solve the maze by itself by simply running around and try to find the exit without the help of the penguin nor gorilla.

For the second playtest we added multiple rocks outside of the pressure plate room in level 3. This ultimately led to the gorilla having the first instinct of dropping rocks on every pressure plate, because that mechanic had been introduced and actively encouraged in the previous level. This meant that for the first two groups in the playtest, all of the pressure plates were activated during the entire level. This rendered the pressure plates useless, and the player in the control room inactive. To mitigate these problems, we forbade the other groups from using these exploits.

For the data analysis, sources of error mainly stemmed from the inherent variability in the data collection. Different researchers could have varying interpretations of the same situation when writing down their observations during the playtest and the interview. The researchers took turns observing and interviewing the participants, which adds individual variance to the dataset.

7

Conclusion

The purpose of this study was to investigate how collaboration can be encouraged in games, specifically three-player games. This was done through iterative development of the three-player game ZooBreak. The game contains three different playable levels, where each level is primarily designed around a collaborative game design pattern; *asymmetric roles*, *concurrency* and *asymmetric information*, respectively. This enabled the application and evaluation of collaborative game design theory through user feedback.

The game was playtested throughout its development and iteratively improved on based on the feedback gathered. The results of the playtests showed that the implemented patterns were generally effective in encouraging collaboration between players. However, some side effects of pattern implementations were also identified. In particular, patterns that were focused on separating players, or distributing information unevenly, were less effective. For example, two players were sometimes observed actively collaborating, while the third player was passively waiting. This indicates some additional challenges involved in designing a collaborative game for three players. This is due to the increased difficulty in balancing gameplay, and ensuring equal participation, between three players rather than two.

For future studies, further iterations and evaluations of the implementation of the current patterns may find ways to reduce the identified side effects. It would also be natural to explore further collaborative patterns beyond the current three levels. Overall, this project has shown the effective use of collaborative game design patterns for encouraging communication, coordination, and collaboration in three-player games. Thus, it lays the groundwork for future research and development.

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A

Appendix

Name:

Age:

Program:

Have you played any collaborative games before? Do you have any prior experience with game development?

How was your overall experience with the game?

Collaboration

How was the collaboration?

When did the collaboration work the best? For example, when did you all agree on a common plan, when did you help each other effectively, etc.

- Any specific level?
- Anything specific within a level?

When did the collaboration work less well? For example, when did you do things on your own without keeping track of the other players; When did you do things that did not aid the progression of the game; When did you do nothing, etc.

- Any specific level?
- Anything within a level which made it difficult or unnecessary to collaborate?

Did the game ever feel like three separate games (completely disconnected players)?

How do you feel about your co-players after working together? Do you feel like you have gotten closer to the group?

Asymmetric roles

Which role did you have?

What did you like/dislike about it?

Did you role feel important?

Did all the roles feel equally important? If not, rank them from 1 to 3 with 1 being the most important

Would you choose to play as the same role again?

Three players

Did it feel balanced to play as three?

- Were there ever any duos in the trio? When?
- When was the game the most/least balanced?
- Was there any difference between levels?

How invested were you in the other players' actions?

- When did you know what the others were up to?
- When was it unclear?

Communication

Did you feel like you had to communicate to succeed, or did you complete the game by intuition?

What did you communicate the most about (in the different levels)?

Did all levels require the same amount of communication?

Leadership

Did anybody take on the role of a leader? If so, do you think it was connected to the role they had?

Design

Was anything in the game difficult to understand?

Conclusion

Anything to add?

Figure A.1: The questions asked to the participants of each playtest