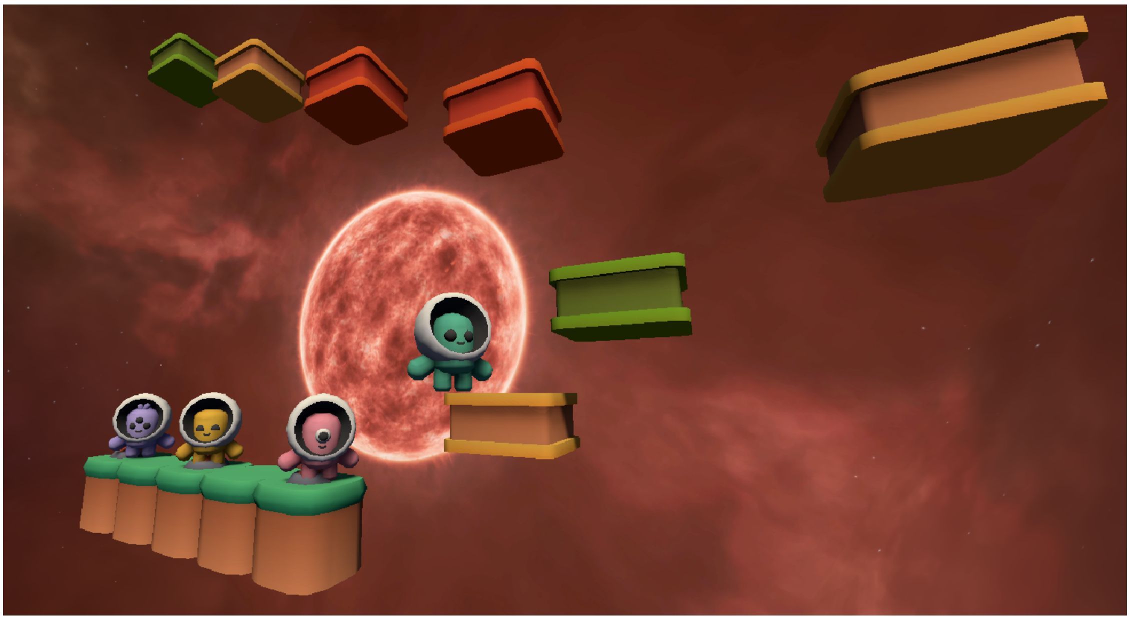

Pixel Pals — Design, study, and evaluation of a collaborative game

Bachelor's thesis in Computer science and engineering

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Abstract

This report measures how collaborative different Game Design Patterns are by creating a four-player collaborative game, holding playtesting sessions, and analyzing the data collected from them. The project used an iterative approach to game creation, and for the analysis, Cooperative Performance Metrics were employed. The project annotates which of the patterns *Concurrency*, *Complementary roles*, *Synergies between abilities*, *Shared puzzles*, *Separation gate*, *Gathering gate*, *Encrypted information*, *Indirect actions*, and *Shared resources* give results in which metrics and tries to give an estimate of what patterns make for the most collaborative experience.

Sammandrag

Denna rapport mäter mängden kollaboration som olika Game Design Patterns ger genom att skapa ett samarbetsspel för fyra spelare, hålla i playtesting sessioner, och analysera den insamlade datan från dem. Projektet använde ett iterativt tillvägagångssätt till spelskapande, och för analysen användes Cooperative Performance Metrics. Projektet utforskar vilka av mönstren *Concurrency*, *Complementary roles*, *Synergies between abilities*, *Shared puzzles*, *Separation gate*, *Gathering gate*, *Encrypted information*, *Indirect actions*, och *Shared resources* som ger resultat i vilka mätetal och försöker att bedöma vilka mönster som medför mest kollaboration.

Keywords: iterative process, collaborative, game, game design patterns, four-player

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We express our gratitude to our supervisor Olof Torgersson for guiding and supporting us throughout this project. We would also like to thank the people who took their time testing and supplied feedback to our game. Furthermore we want to thank those at the Chalmers Library for helping us with the questions we have had.

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1

Introduction

Multiplayer games are a highly popular type of game in today's gaming industry, in fact the top five games listed as most played on Steam as of March 5, 2026 incorporate some kind of multiplayer aspect [1].

The introduction of this report presents the initial parts such as the purpose and scope of the project, as well as the social and ethical aspects considered by the group and the use of AI throughout the project.

1.1 Purpose

This purpose of this project is to create, study, and evaluate a four-player collaborative game. The study will involve analyzing the effectiveness of Game Design Patterns in facilitating collaboration. This will be used to design a game that will promote teamwork and communication by requiring players to collaborate, share responsibilities, and solve challenges together.

1.2 Scope

For this project, a target demographic of 18 to 30 year olds is chosen, who preferably have some sort of computer experience. This is mainly done in order to make the game familiar and engaging to the people who are expected as playtesters, as people of this demographic usually have some experience with game mechanics and video games. This is important because the focus is on making and measuring a collaborative experience and making a game that appeals to the testers will allow more emphasis to be put into that.

Because this project puts focus on evaluating what leads to collaboration in games, no focus will be put on the technical aspect of implementing these patterns in this report. Furthermore, this project will only be examining existing design principles regarding collaboration in video games and will not attempt to invent any new ones.

1.3 Social and ethical aspects

This project comes with a collection of unique social and ethical aspects to consider, both with respect to the development process and the analysis. First, during the design phase, it will be important to make sure that the finished product does not contain any message that could be considered offensive, harmful, or unethical.

During each iterations testing phase, it is important to secure proper consent from each participant before collecting any data, and make sure that there is full transparency regarding what data will be collected, and what it will be used for. This will be done by having the participants sign a consent form before any testing takes place, see Appendix A.1.

Besides thinking about what content is presented in the game, it is crucial to be mindful about infringing on anyone's copyright when choosing game assets. When using any game assets (such as models, textures, sounds, etc.) they must be approved under a license that fits the project. It must be ensured that any given asset, free or paid, is not being redistributed under the wrong license.

The game is meant to be a socially rewarding experience as well as an exercise in teamwork that might bring a welcoming atmosphere to the players.

1.4 Artificial intelligence

Artificial intelligence (AI) will be used to gather information, but all information will be verified by other sources. Another way AI will be used is to help format the report correctly in Overleaf and to generate images used in the project. It will also be used to help when writing code to implement different features correctly.

The different types of AI tools that will be used are: ChatGPT v.5.2, Claude 4.6

2

Theory

According to Zagal *et al.* [2], games meant for more than one player can be categorized into the following categories: competitive, cooperative, and collaborative. Competitive games are games where players form strategies to defeat an opposing team [2]. Cooperative games are games where players are allowed to work alongside each other, but may still pursue individual goals and receive individual rewards, i.e. collaboration is optional rather than required [2]. Collaborative games are ones in which all players have the same goals, payoffs, and outcomes, making collaboration a necessity rather than an option [2].

Despite a recent surge in popularity for games in the cooperation and collaboration category [3], most of the multiplayer games released are of the competitive variety, with cooperative and collaborative games making up only 6% of the market together, despite accounting for 36% of the games being sold [3]. This highlights a clear discrepancy between the commercial success of collaborative games and their relatively limited representation in practical game development.

Although there has been research done on both cooperative and collaborative games, most of the research has been studying games that would be considered cooperative, since players often have different goals and only choose to collaborate in certain situations when it benefits them, e.g. a guild doing a boss raid in World of Warcraft. This is due to the fact that the categories used by Zagal *et al.* [2] do not see widespread use, and many gamers consider both cooperative and collaborative games as *Co-Op games*.

As such, the topic is particularly relevant to players who engage with collaborative games, as well as to game designers and researchers aiming to better understand and design systems that support meaningful collaboration between players. In addition, games that focus on collaboration and insights from collaborative game design have been shown to be applicable in contexts where structured collaboration and communication are important, such as educational or social environments involving individuals who experience difficulties with communication [4].

2.1 Game Design Theory

Game Design Theory focuses on how games create meaningful player experiences through rules, systems, and interaction. The book *Rules of Play* describes game design as “Game design is the process by which a designer creates a context to be encountered by a participant, from which meaning emerges” [5, p. 80]. The authors explain that players create meaning by interacting with the game system and its “[...] spaces, objects, narratives, and behaviors” [5, p. 41].

Rules of Play also explains that game design is difficult to define because the concept of design itself can have many meanings. Design can be understood as a process, practice, product, or way of thinking [5, p. 40]. The book further describes game design fundamentals as systems, interactivity, player choice, action, outcome, and social interaction [5, Ch. 1].

Another concept in *Rules of Play* is the framework “Rules, Play, Culture”, where rules describe the game system, play describes the player experience, and culture describes the larger social context surrounding the game [5, p. 6]. The authors explain that games can be viewed as both closed and open systems depending on how they are analyzed [5, pp. 96-97].

The Mechanics-Aesthetics-Dynamics (MDA) framework, written by Hunicke, LeBlanc, and Zubek, is used to divide games into three core components: Mechanics, Dynamics, and Aesthetics [6]. Mechanics describe the rules and systems of the game, dynamics describe behaviors emerging from player interaction, and aesthetics describe the emotional experiences created for the player [6].

2.2 Game Design Patterns

When designing and talking about games, it is useful to use the language of Game Design Patterns [7]. Game Design Patterns describe parts of the interaction that a player can have within a game, i.e., in what ways a player can affect the game state [7]. These patterns make it easier to communicate ideas about how a game should work and be experienced, as well as allowing for easier analysis of games. They act as a common language for game developers as well as for people who play games [7].

There are a great amount of Game Design Patterns that can help and guide the developer when making a collaborative game. Some patterns are quite common and appear in several games [8]. One pattern that is essential for a game to be collaborative is *Shared goal*, which means that all players must work towards the same objective [8]. Although a wide range of collaborative patterns have been identified in Game Design Theory, here is a selection of patterns that are particularly relevant to this project [8], [9], [10], [11]:

- **Concurrency**: Operating one or more objects simultaneously that could not be operated by a single player alone. E.g. two players operating two buttons simultaneously in order to unlock a door in *Lego Star Wars*;

- **Complementary roles**: Giving players different roles, with different abilities, to perform during a game session. E.g. playing as different classes in an MMORPG such as *World of Warcraft*;
- **Synergies between abilities**: Giving player characters different abilities which can be used together for stronger or different effects. E.g. igniting an enemy with a spell after they have been struck by *Brewmaster's Cinder Brew* in *Dota 2*;
- **Shared puzzles**: Giving players a logical problem which they have to figure out the solution to together. E.g. conceptually *Portal 2*, *It Takes Two*, and *Pico Park*;
- **Separation gate**: Forcing players to split up by allowing only a certain number of players to continue while the others need to stay behind. E.g. players solving a puzzle together at two different parts of a test chamber in *Portal 2*;
- **Gathering gate**: Forcing the players to wait for each other by only allowing them to continue together. E.g. waiting for other players at the spaceship before taking off in *Lethal Company*;
- **Encrypted information**: Giving only a subset of the players certain information about the game state. E.g. knowing everyone's hand except your own in *Hanabi*;
- **Indirect actions**: Giving only a subset of players some information about the game state that requires another player to act. E.g. giving instructions to the person defusing the bomb in *Keep Talking and Nobody Explodes*.
- **Shared resources**: All players share a pool of resources from which everyone may add or subtract. E.g. players take and give tokens from the middle in the card game *Hanabi*.

2.3 Collaborative Game Design

Understanding how Game Design Patterns influence player interaction is central to the design of a four-player collaborative game. In addition to Game Design Patterns, Zagal *et al.* [2] provide four lessons to help developers make a successful collaborative game:

1. To highlight problems of competitiveness, a collaborative game should introduce a tension between perceived individual utility and team utility;
2. To further highlight problems of competitiveness, individual players should be allowed to make decisions and take actions without the consent of the team;

3. Players must be able to trace payoffs back to their decisions;

4. To encourage team members to make selfless decisions, a collaborative game should bestow different abilities or responsibility.

In addition to these lessons, they mention three pitfalls to avoid when making such a game [2]:

1. To avoid the game degenerating into one player making the decisions for the team, collaborative games have to provide a sufficient rationale for collaboration;

2. For a game to be engaging, players need to care about the outcome, and that outcome should have a satisfying result;

3. For a collaborative game to be enjoyable multiple times, the experience needs to be different each time and the presented challenge needs to evolve.

From a psychological perspective, collaborative games can promote social bonding, shared problem-solving, and engagement [4]. Making them particularly interesting in contexts related to learning and social interaction.

Despite the existence of established patterns, further research is needed to determine which approaches are most effective in collaborative game design and in promoting player collaboration. This challenge forms the basis for this project, which aims to investigate and design a collaborative game experience for four players.

2.4 Iterative Process

During the development, an iterative design process was used, shown in Figure 2.1. This process is a development methodology in which the game was created through repeated cycles of designing, implementing, testing, and evaluating [5, pp.11-15].

"The rule of the Loop: The more times you test and improve your design the better your game will be" [12, p. 95]. Through continuous iterations, the game evolved and started to take shape with small improvements over time. This process was important since it is not fully possible to predict the experience of a game and therefore playing a game is an act of designing [5, pp. 11-15]. For this reason, it is important for the development to get through as many iterations as possible, to try out all the implementations and the effect it would have on the game itself and the experience of playing the game.

It has been observed that 80% of video game developers claim to be using some version of agile development [12, pp. 89-99]. Two of the core concepts in agile methods are flexible goals and a prioritized backlog [12, pp. 89-99].

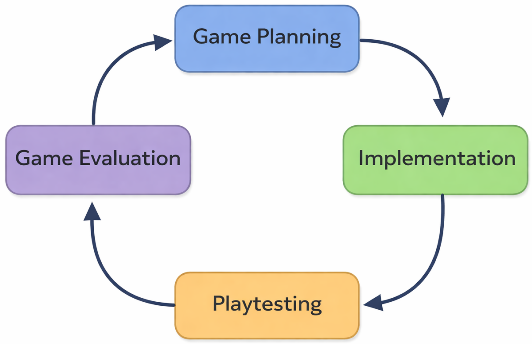


Figure 2.1: The iterative game development process consisting of planning, implementation, playtesting, and evaluation. (Created with ChatGPT v.5.2, 2026)

2.5 Game Evaluation

There are many ways games can be evaluated, the evaluation process usually considers both the technical quality of the game as well as the player experience. A common way to evaluate is through gameplay. Through this method, the evaluators gain a good perception of how the game feels to play, as well as whether the controls are responsive and the mechanics are engaging.

2.5.1 Cooperative Performance Metrics

One way of evaluating cooperative interaction during gameplay is through the behavior based playtesting framework proposed by El-Nasr *et al.* [11]. This method uses Cooperative Performance Metrics (CPM) to evaluate cooperative gameplay through a structured analysis of observable player behaviors [11]. The result of that study has been validated through inter-rated agreement and was created through an iterative process involving experts and team reviews [11]. In said study, different games were played in the playtesting sessions and the observed CPMs were compared with each other to see the differences in collaboration between the different games [11].

Since the data is measured based on human observation and coding, there is a risk of bias and inconsistency. This is usually evaluated by measuring the inter-rater reliability, and in their study the inter-rater reliability was measured using Cohen's kappa to minimize these limitations and ensure a consistent classification of behaviors [11], [13]. Cohen's kappa is a formula that looks at how much reviewers agree beyond what could be expected by chance [13].

For the playtesting of this study, a simplified percentage agreement method will be used to assess CPMs coding consistency [13]. This is to ensure that the definitions of the CPMs are sufficiently structured and clear enough for different reviewers to reach consistent coding decisions. Important to mention that a perfect inter-rate reliability is rarely expected in observational studies because of the subjective nature of human interaction [13]. The following formula represents simple percentage agreement [13]:

$$\text{Agreement} = \frac{\text{Number of agreements}}{\text{Total coding decisions}} \times 100$$

The CPMs introduced by El Nasr *et al.* [11] are the following:

- **Laughter or excitement**: Instances during which all participants laughed, verbally expressed enjoyment, or exhibited nonverbal facial expressions indicative of happiness or excitement;
- **Worked out strategies**: Occurrences in which participants verbalized their thought processes while collaboratively solving a shared challenge and navigating the environment together;
- **Helping each other**: Moments when participants supported one another by discussing controls and mechanics, guiding each other through obstacles, and offering help during challenges;
- **Global strategies**: Refers to instances where participants demonstrate structured teamwork through the assignment of complementary roles;
- **Waited for each other**: Situations in which participants wait for others to catch up;
- **Got in each other's way**: Events in which participants take actions that interfere with one another.

The latter two CPMs could build frustration among participants, and therefore a good collaborative game should minimize the possibility of these events occurring [11].

Beyond these CPMs mentioned, the group decided to further expand the framework by adding these relevant CPMs to enable a more in depth analysis of the gameplay:

- **Questions**: Instances in which participants verbally requested information from other participants;
- **Blaming each other**: Moments in which participants explicitly assigned blame for unsuccessful outcomes to another participant.

The value in adding these two CPM categories is to broaden the range of the data that is gathered, and strengthen the framework by capturing the interactions patterns not fully represented by the original CPM model.

Adding the CPM *Blaming each other* introduces a way to capture a negative social behavior and complement the CPM *Got in each other's way* by focusing on verbal reactions rather than only interfering actions in gameplay. While adding the CPM

Questions will help to better understand how participants rely on one another. This will also reveal if there are any unclear game mechanics or objectives that might need improvements.

Together, these additions may help identify outliers in where collaboration differs from the norm. By examining both typical and atypical interactions, this playtesting can provide a more accurate understanding of what adjustments may improve the overall player experience.

2.5.2 Game Experience Questionnaire

A widely used questionnaire in measuring game experience is *The Game Experience Questionnaire* (GEQ) [14], [15]. Another commonly used evaluation tool in game experience is the *Player Experience of Need Satisfactions* (PENS) [15]. The GEQ focuses more directly on the game experience during and after the game, such as enjoyment, frustration, and connection to others [15]. Whereas PENS builds on Self-Determination Theory and focuses on the psychological needs that affect motivation [15].

In this study, the focus is on evaluating the collaboration in the game using CPMs that measure the amount of certain actions and emotions during direct gameplay. Since PENS focuses less on direct emotions during a specific playtesting, the study uses the GEQ as a base for the survey to complement the way to measure collaboration.

2.5.3 Playtesting

Playtesting is a user research method used in game development to evaluate design decisions based on player feedback with the goal of improving player experience [16]. Iterative analysis and testing are important parts of the game design process, where qualitative and quantitative evaluations are used to refine gameplay systems and player experience [6]. “MDA supports a formal, iterative approach to design and tuning.” through continuous evaluation and refinement of gameplay systems and player experiences [6].

Developers can use less structured playtesting methods focused on gathering natural player behavior and gameplay interactions [16]. These methods are used to observe player behavior, communication, and reactions during gameplay sessions [16]. The authors further describe that less structured playtesting approaches can generate more subjective and difficult-to-analyze data due to unclear research objectives and evaluation criteria [16].

When players are observed during playtesting their behavior could change compared to when not [17].

3
Method

This chapter presents the methodology of how the game, Pixel Pals, was developed using the iterative process, with all the steps of the process explained in more detail.

3.1 Game Planning

In this stage of the cycle, a list of features was made and then prioritized in order of what was essential for this iteration. In Kanban, the feature and their priority were listed and assigned among the group members. It was crucial to remain flexible regarding the goals and plans established during the brainstorming and paper prototyping phases, as this aligned with agile development principles and enabled the delivery of a higher-quality end product.

3.2 Implementation

In this stage, the development of the features decided on in the previous step were implemented in Unity, using the programming language C#. Each feature was coded in a different branch on git.chalmers and later merged into the main branch. Before the final merge, each feature was reviewed by another member of the group to ensure correctness and that no bugs were present.

3.3 Playtesting

After each iteration, a playtesting session was carried out to test the current game. Details regarding the selection of participants, setup, procedure, and data collection are further explained in this section.

3.3.1 Participants

Playtesting was conducted throughout all iterations of the project, with participants recruited as volunteers. To reduce bias in their behavior, they were not informed about the specific research objectives of the study, but rather that it involved testing a collaborative game. The testers only played in one session, with new players recruited every time.

Before participating, all individuals consented to take part in a bachelor's thesis playtesting session and signed a consent form (Appendix A.1) agreeing to gameplay and voice recording for analysis, as well as completing a post-session survey.

3.3.2 Setup

Each playtesting session consisted of four players, each assigned to their own computer with the game installed and connected to the internet. The gameplay of all participants was streamed through Discord to a fifth computer, where the session was recorded. This setup captured all player screens simultaneously along with their voice communication, as shown in Figure 3.1. By centralizing the recording into a single synchronized view, all player screens could be observed simultaneously without requiring post-session synchronization of separate recordings.

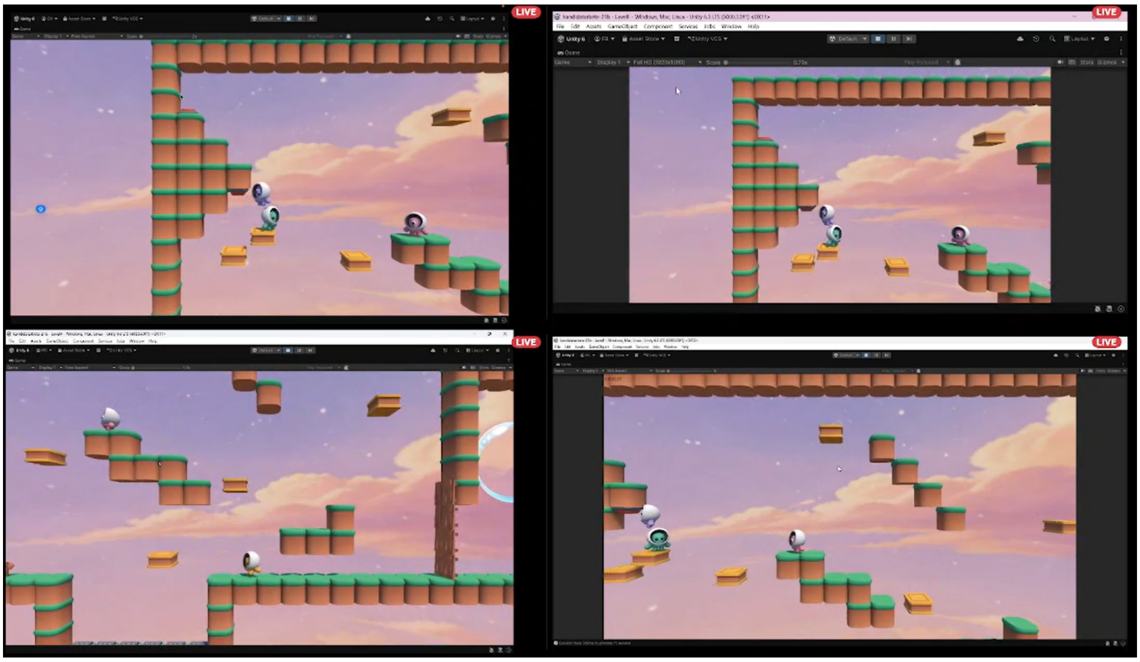


Figure 3.1: Screenshot of the fifth computer recording the gameplay of all players and their voices during playtesting.

3.3.3 Procedure

Playtesting was integrated into each of the four iterations of the development process, serving both as a means of collecting data on collaborative behavior and as a tool for identifying design issues, for example, improving the movement and technical faults, such as bugs. Having a sufficiently stable and polished version of the game before the playtesting sessions was important because these issues could otherwise interfere with the validity of observed player interactions.

An unstructured playtesting approach was used to allow natural collaboration and communication behaviors to emerge during gameplay. The only objective given to participants was to complete the levels collaboratively. Before starting, players were informed of the basic control movements. No further guidance on how to solve the levels was provided during gameplay, allowing participants to rely on their own communication and strategies.

Each session was based on a selected set of levels and typically lasted between 45 and 60 minutes, depending on how long it took the players to complete the levels, and was adjusted based on the participants availability.

At least four researchers were present during each session to set up the environment and observe the players. In general, no intervention was made during gameplay except when necessary, such as resolving critical bugs, limiting excessive time spent on a task by introducing a time constraint, or providing minimal hints if players were unable to progress for an extended period of time.

3.3.4 Survey

After a playtesting session, the participants were asked to anonymously fill out a post-game survey to capture their experiences during play. The survey consists of quantitative questions where answers use a five-point Likert scale ranging from 1 (*Not at all*) to 5 (*Extremely*). An additional qualitative question with an open-ended response was included at the end to allow participants to share any other insights or thoughts about the game. The responses from this survey were used to obtain feedback during development to improve the game iteratively. The survey items are listed in Table 3.1.

Table 3.1: Game Survey Items

Survey Statement	**Scale**
I thought it was fun	1–5
I felt irritable	1–5
I felt challenged	1–5
I felt that the controls were good	1–5
I found it enjoyable to be with the others	1–5
I felt revengeful	1–5
I felt connected to the others	1–5
I paid close attention to the others	1–5
I felt jealous about the others	1–5
My actions depended on the others' actions	1–5
I found it a waste of time	1–5
Any other comments?	Open response

Scale: 1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Fairly, 5 = Extremely.

3.4 Game Evaluation

With the help of the recordings and responses to the survey from each playtesting session, the group evaluated and analyzed the data and information collected with the aim of reaching results and conclusions that could be presented further on in the report. The method used for evaluation and analysis is explained in more detail in the following sections.

3.4.1 Cooperative Performance Metrics

This study used CPMs to evaluate the collaborative gameplay through playtesting sessions. The observers in these sessions looked at the CPMs introduced by El Nasr *et al.* [11], as well as two additional ones added by the group, as mentioned previously.

Rather than conducting comparisons between games as El Nasr *et al.* [11] did, this study examined the differences between levels within a single game. The goal was to provide information on which CPMs are associated with what specific combination of Game Design Patterns and how these combinations would influence the level of collaboration that existed among the players.

3.4.2 Data Analysis

The CPMs were annotated parts-wise and summarized from the data gathered in playtesting sessions two and four. This was done in order to cleanly map the Game Design Patterns to which CPM they resulted in. The first, third, and fifth playtesting session was excluded from the main CPM result due to inconsistent data annotation.

When notating CPMs, repeated events were only marked once if they occurred for the same reason. For example, laughter caused by accidentally falling into a hole was recorded only the first time it occurred and was not marked again if repeated for the same reason in the same part of the level. However, if the same event occurred for a different reason, for example, being pushed down a hole, it was recorded again. This approach was used to avoid an excessive number of CPMs caused by repeated reactions that were not relevant to the measurement of patterns. For instance, a player repeatedly falling due to poor gameplay performance was considered to be more reflective of the player's skill level, rather than of the Games Design Patterns.

4

Development

In this chapter, the brainstorming process and the different iterations are described along with their respective playtesting, as can be seen in Figure 4.1.

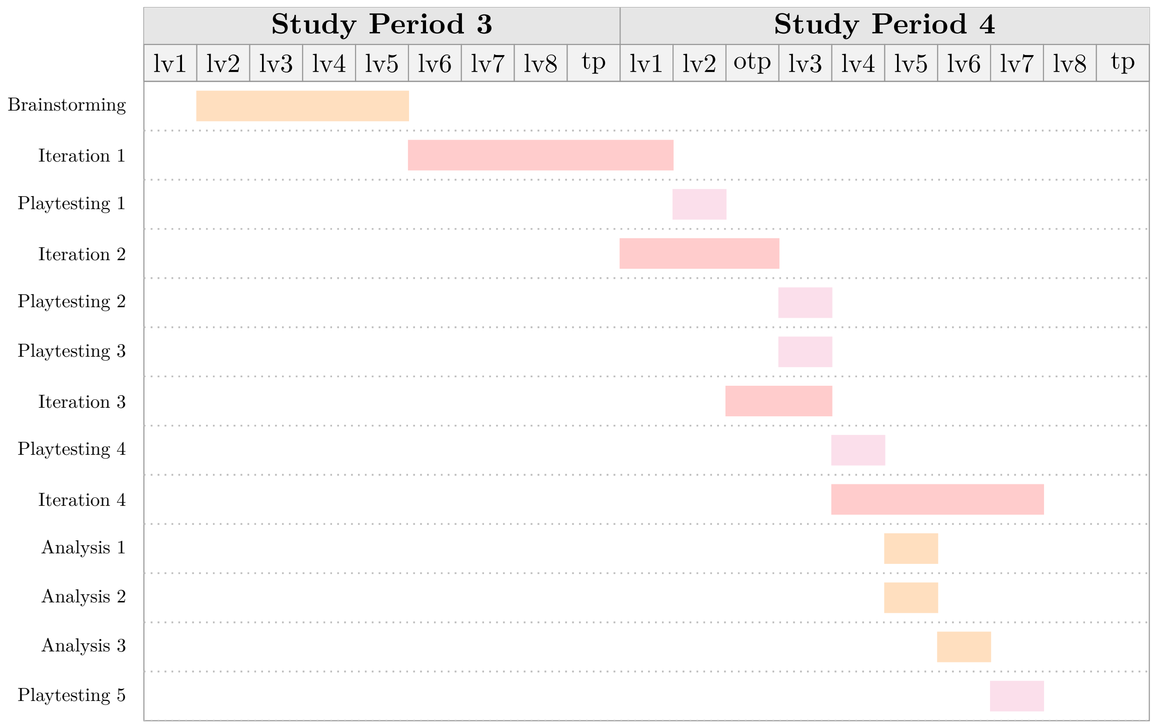


Figure 4.1: GANTT chart of the projects different iterations and playtestings. The colors are coordinated to match the responding phases: darker pink is for iteration, light pink is for playtesting, orange is for brainstorming and analysis.

4.1 Brainstorming

The first stage of development involved deciding what type of game to make. This process was started by brainstorming ideas for games that would involve collaboration. The ideas that came from this varied from collaborative versions of typical single player games, derivatives of existing collaborative games, and vague ideas that we struggled with putting to words exactly how the game would work.

After further discussions, four ideas were selected based on the grounds that they involved enough collaboration and were considered to be reasonable to implement in the given time frame. The ideas were the following:

- A city builder game where each player would have an assigned role or "department" they would be in control of;
- A card game where players would defeat bosses by playing cards that could combine with other cards for empowering (or diminishing) effects;
- A platformer inspired by Pico Park, where players would work together to solve simple puzzles;
- An Overcooked inspired game where players would have to assign roles to each other in order to finish enough tasks before the clock runs out.

Discussion on exactly what game the group wanted to make continued and the choice of the final game idea was based on a multi criteria analysis approach. Each person would rate the four game ideas from 1 to 10 on five different criteria:

- To what extent will the data produced from playtesting be of use to us;
- How enjoyable will the game be to produce;
- How enjoyable will the game be to play;
- How collaborative do we deem the idea to be;
- Is this idea feasible to produce within the time frame.

Each member of the group also rated these criteria on how important they thought they were, and a score for each game was calculated using and their weighted average, the result can be seen in Table 4.1.

Table 4.1: Multi-criteria analysis of game concepts

Developer	Pico Park	Slay the Spire	City Builder	Overcooked
1	8,1	6,2	2,3	6,0
2	9,2	6,1	4,1	4,8
3	9,2	8,5	4,8	6,2
4	6,1	5,8	5,7	8,1
5	3,8	6,4	5,8	5,3
6	8,5	5,2	3,6	6,9
Grade	7,5	6,4	4,4	6,2

After this final analysis, we decided on creating the Pico Park inspired platformer idea, since it was deemed possible to implement within the time frame, enjoyable to produce and play, and the majority thought that it would provide great data for the final report. It was decided that the name of the game would be Pixel Pals.

Next, we had to decide on what types of assets to use in the game, 2D or 3D. Here, the discussion was much more brief. We talked about the benefits and drawbacks of the two options; 2D would be easier to create, but would not stray far enough from the work we were taking inspiration from. 3D on the other hand would give a wholly new look to the game, but adding another axis could fundamentally change how the game works. It was decided to use 3D assets but still limit the players movement to the X- and Y-axes, i.e. 2.5D.

4.2 Iteration 1

The focus of the first iteration was to ensure that a simple multiplayer platformer game was working and considerable time was spent evaluating Unity's networking frameworks. A proof of concept confirmed that Unity could support multiplayer interaction across different processes on the same machine, using Unity's NetCode for GameObjects, and Unity Relay to host connections between them, allowing the game to be tested easily on campus grounds.

During this iteration it was decided that the project would use existing assets instead of custom made since this would allow for greater focus on the implementation of Game Design Patterns, and the testing process. For the project, a selection of assets from *Platformer Kit* on kenney.nl were used. Furthermore, all the parts needed for the base of the game were created, such as players, tiles, spawn points, and a goal.

4.2.1 Playtesting 1

During this iteration, one level and one feature were playtested. The outcome of this test iteration was mainly the need for stricter categorization of the data. The decision was made to not only group the data by CPM but also by which Game Design Pattern triggered the communication. This was done in order to make comparison between different patterns easier. One of the patterns tested in the level was *Concurrency*, where the players had to build a tower in order to cross a gap that was too wide to be cleared alone, which can be seen in Figure 4.2. Another pattern tested was *Indirect actions*, where one player had to instruct the rest of the players on which buttons they had to stand on in order to reveal blocks to overcome a high wall.

The feature that was tested was the bubble, which was done in a simplified test environment. This feature locks all players in a bubble in which they control one direction each and have to navigate together. The most prominent patterns tested in this feature are *Complementary roles* and *Concurrency.*

During this playtesting session, CPMs were annotated in real time while observing the gameplay session. The purpose of this approach was to immediately docu-

Figure 4.2: The players working together in order to clear a gap in level 1, showing *Concurrency*.

ment collaborative interactions and player reactions during gameplay. However, this method proved difficult in practice because all four players needed to be observed simultaneously while also following the gameplay itself. As a result, some reactions and interactions were likely overlooked during the live notation process and therefore it was not used in the main CPM analysis.

4.3 Iteration 2

After collecting and analyzing the data from the first playtesting session, the second iteration began. This iteration focused on creating more levels with more patterns to test. Three more levels were created: level 2, level 3, and level 4.

Level 2, which focused mostly on the patterns *Concurrency* and *Separation gate*, was where the players would need to first solve a platforming puzzle that required all four players in order to reach and press all four buttons simultaneously. Doing this opened up a gate to the next part of the level where the players were all placed in the same bubble tested in iteration 1.

The next level, level 3, focused mainly on the patterns *Separation gate* and *Encrypted information*. The players would first solve a platforming puzzle, with the biggest difference compared to the other platforming puzzles being the fact that one player would have to stay behind and wait for information while the rest were solving platforming puzzles to collect it. Next, they would solve a memory based puzzle where clues given in the first puzzle were needed in order to make it to the end.

The final level for this iteration was level 4, which focused on the patterns *Encrypted* *information* and *Indirect action*. Players would step on buttons that revealed different platforms, and only the player standing on a certain button could see certain platforms, not being able to see the other platforms. The idea was that three players would stand on each button and give information about where the platforms were placed to the last player, who was not able to see any platforms, trying to navigate their way by the trust and direction of the information given by the other players. The paper prototype of this is illustrated in Figure 4.3.

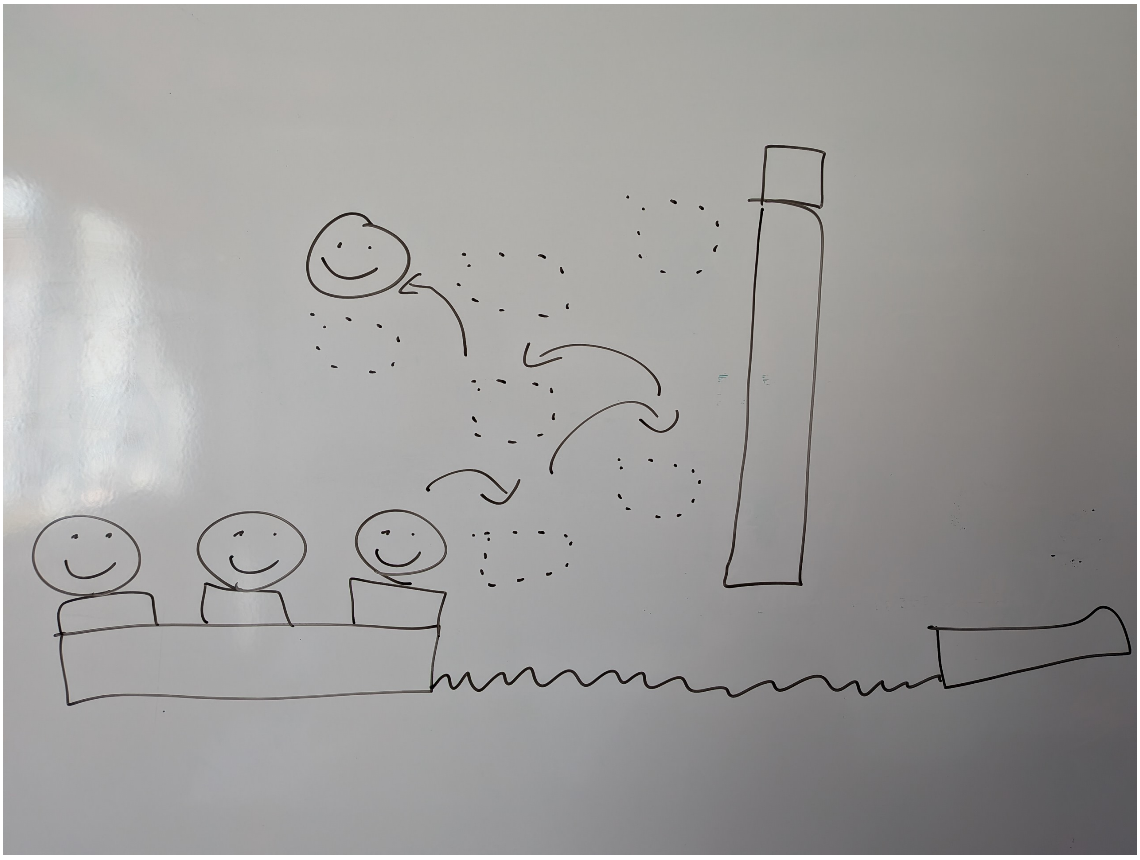


Figure 4.3: Paper Prototype of level 4

4.3.1 Playtesting 2 & 3

Two playtesting sessions were held during this iteration using the updated categorization method developed after the first iteration. In both sessions, the players tested the four levels that had been created. These two sessions led to a few more insights and questions about the process that were discussed within the team.

One identified issue was that the game on the client side suffered from delayed responsiveness and the controls were a bit slippery. Together, these factors led to a game that was sometimes more difficult than intended, making the collaborative aspect of the game less of a focus than the platforming at times. Another important observation was that players sometimes struggled to understand what they were supposed to do in the level at first. Sometimes, this was by design, to let the players discuss ideas and work out strategies. Other times, it was considered an unintended level design issue.

After some discussion, it was deemed that there was not enough time to investigate and solve the network issues, but that work would be put into making the controls more forgiving. This approach was taken in order to generate better data from tests without requiring excessive time.

Efforts were also made to clarify the objective of levels, by allowing the players to see more of the screen and giving hints to the players in the game. During the sessions, players had gotten stuck in some levels by making moves that were not anticipated. This led to having to restart the levels. Focus was put on addressing these errors and a respawn button was added in order to make it easier to reset the game when needed.

The second playtesting session was observed both in real time and recorded for later analysis. Recording the sessions made it possible to revisit interactions and compare them with live CPM annotations. Through this process, it became clear that reviewing recorded gameplay provided more accurate and consistent CPM data than live observation alone. The recordings also allowed interactions to be analyzed in greater detail without the pressure of real-time notation.

Following the results of the previous playtest, the third playtest session and all playtests going forward relied entirely on recorded gameplay analysis instead of live CPM notation.

The recording of the third playtest got corrupted and therefore it was not used in the main CPM analysis.

4.4 Iteration 3

As the third iteration began, the group once again analyzed the data from previous playtesting sessions. The development in this iteration focused mostly on debugging and smaller tweaks on the levels based on observations during the previous playtesting sessions. These were changes such as preventing softlocks, adjusting gap sizes, and adding indicators to nudge the players in the right direction where they previously had trouble understanding the puzzle. This was both to polish the final product and to improve the playing experience for testers, making it easier to focus on the parts the group wants to test rather than getting stuck on bugs.

In addition to resolving bugs and tweaking levels, the group started the process of analyzing and compiling results and data from playtesting sessions. The group started quantifying and categorizing the different CPMs by defining which ones were in the same category and what they all meant for the intended research of this study.

4.4.1 Playtesting 4

In the third iteration, only one playtesting session was held. Once again, the testers played the same four levels as the previous playtesters. However, this time with the bug fixes and tweaks mentioned above, improving the playing experience. This session strengthened previous thoughts; that the game was intermittently experiencing latency and that the controls were too slippery and quick. As discussed in iteration 2, the latency issue was not easily resolved and therefore would generally be ignored. The controls and movement, however, were discussed and tweaked to make the players feel more in control of their character. The movement speed of the character was lowered and the jumping was slowed down while still preserving the jump height and length as well as possible.

The group also noticed that these playtesters had problems understanding some of the puzzles even after the added indicators. This was briefly discussed after the session, and the group reached the conclusion that the solution for puzzles should not be spoonfed to players, and instead let them solve them using communication and collaboration. This could even increase the amount of collaboration used between players, and therefore improve the product.

4.5 Iteration 4

The fourth iteration introduced a new level designed to test the Game Design Pattern *Shared resources*, but due to time constraints and technical issues, the collected data was limited and therefore not included in the main CPM analysis.

The level was designed around players selling gathered resources for coins, purchasing keys as well as time, and collaboratively progressing towards the goal during time pressure. See Figure 4.4. Two different versions of the level were created: one where the coins were shared between players and another where coins were managed individually.

The purpose of the level was to investigate how shared versus individual resources affected player collaboration and communication. Earlier design concepts for the level were discarded during development because they either placed too much focus on other patterns, such as *Concurrency* and *Gathering gate*, or allowed players to complete the level without relying sufficiently on collaboration.

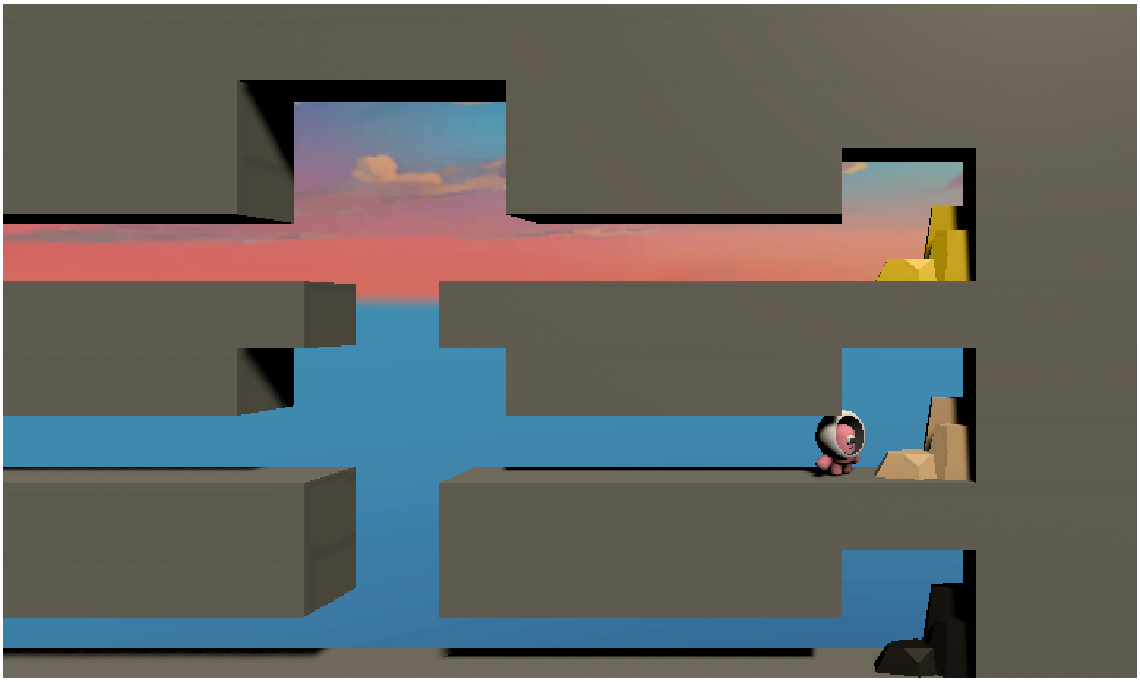


Figure 4.4: Different resources to prioritize in level 5

4.5.1 Playtesting 5

One playtesting session was conducted for level 5. During the session, the players first completed the version with shared resources and then the version with individual resources. The players understood the objective of the level and remained engaged throughout the session, often focusing heavily on resource management and time pressure.

However, during the first three minutes of the gameplay, the audio was not recording, which led to the data not being used for the main CPM analysis. Another problem with the playtesting was the two bugs. This did not affect gameplay as the testers followed the instruction not to abuse them.

Despite this, the playtesting session still provided useful observations regarding the implementation of *Shared resources*. The level appeared to encourage continuous player engagement and coordination through discussions related to resource management and time prioritization. The session highlighted several possible improvements for future iterations, such as adjusting the pacing and expanding the resource system further.

4.6 Analysis iterations

How the CPMs were notated changed during the development. It was a part of the agile process in which flaws got improved upon.

4.6.1 Analysis Iteration 1

During the first analysis iteration, four researchers analyzed the recorded gameplay sessions together simultaneously. This allowed the group to discuss and establish a more consistent understanding of how the CPMs should be categorized and annotated. However, several player interactions were subjective and difficult to classify consistently. For example, some interactions could be interpreted as both *Questions* and *Worked out strategies*, making it unclear whether they should be categorized under one CPM or multiple CPMs. The process also proved very time-consuming, as disagreements regarding CPM categorization frequently occurred.

4.6.2 Analysis Iteration 2

In the second analysis iteration, an agreement-based approach was introduced to reduce subjectivity and improve consistency between researchers. All the researchers annotated the CPMs on their own paper instead. This also reduced the time required for discussions, as disagreements could instead be measured through agreement calculations.

$$\text{Agreement} = \frac{\text{Number of agreements}}{\text{Total coding decisions}} \times 100$$

Another issue identified during this iteration was that some reactions repeatedly occurred for the same underlying reason. For example, a player repeatedly failing the same jump could generate repeated instances of *Laughter or excitement*, artificially increasing CPM counts without necessarily reflecting increased collaboration. To address this issue, a new annotation rule was introduced where repeated reactions caused by the same reason were only noted once. However, if the same type of reaction occurred for a different reason, it was recorded again. This adjustment reduced skewed CPM data and improved the relevance of the collected observations.

4.6.3 Analysis Iteration 3

During the third analysis iteration, each level was broken up into parts in order to easily give a suggestion of what pattern might have triggered the metric, and each possible interaction was discussed before assigning it to a certain metric. This method was utilized to obtain uniform CPMs from the test data and to ensure that no interactions were missed.

The researchers were then divided into pairs and independently analyzed separate gameplay recordings. This reduced the time required for the analysis and made the categorization process more manageable.

The final iteration became the standardized method used to analyze all recorded playtesting sessions.

5
Result

At the end of development, a simple multiplayer platformer game called Pixel Pals was created. In total, it contains six levels, designed around distinct challenges and features. The players take on the roles of four alien creatures, each contributing to the completion of puzzle-focused levels. The result will be analyzing the first four levels. See start lobby in Figure 5.1.

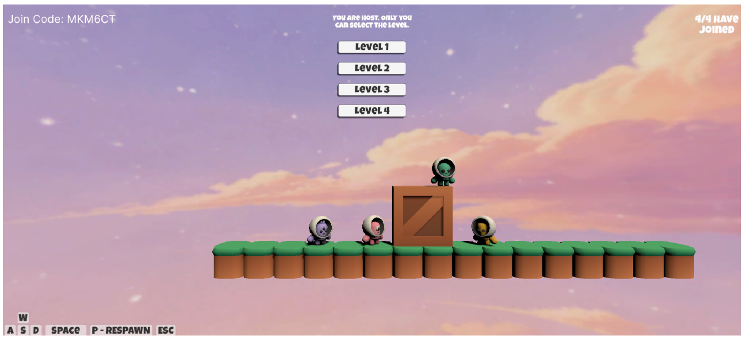


Figure 5.1: Start lobby for Pixel Pals

The gameplay is structured to require collaboration, as no level can be completed by a single player. Instead, most of the challenges rely on coordinated and simultaneous actions of all four players. These include features such as activating multiple buttons in Figure 5.8b, simultaneously steering a bubble in Figure 5.5c, crossing large gaps in Figure 5.3a, and communicating encrypted information in Figure 5.10.

Each level has a variation in how collaboration is implemented, using different combinations of patterns and features. For example, some parts of the levels use *Encrypted information* or *Separation gates* that enhance the required level of communication among the players, while others simply use *Concurrency*, which focuses less on communication and more on mechanical collaboration. A few selected images of different features have been shown for each level, see Figures 5.3, 5.5, 5.7, and 5.10.

The way in which the levels were divided into the different parts and which Game Design Patterns are present are presented visually in Figures 5.2, 5.4, 5.7, and 5.9 and in a structured tabular format in Tables 5.1, 5.2, 5.3, and 5.4. The pattern *Shared goal* is present in all levels, but was not analyzed in this project.

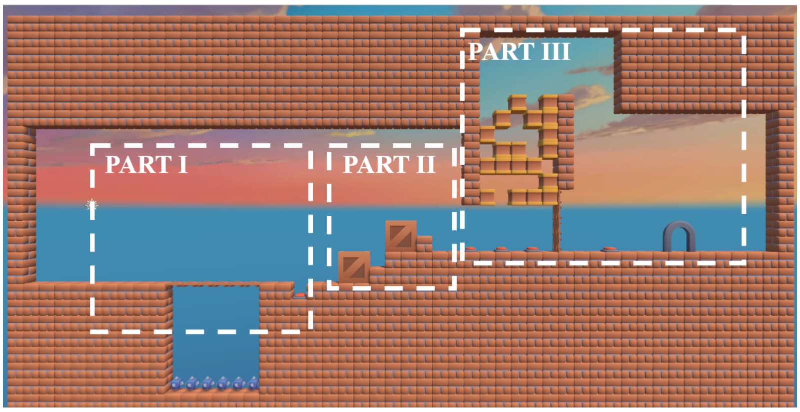
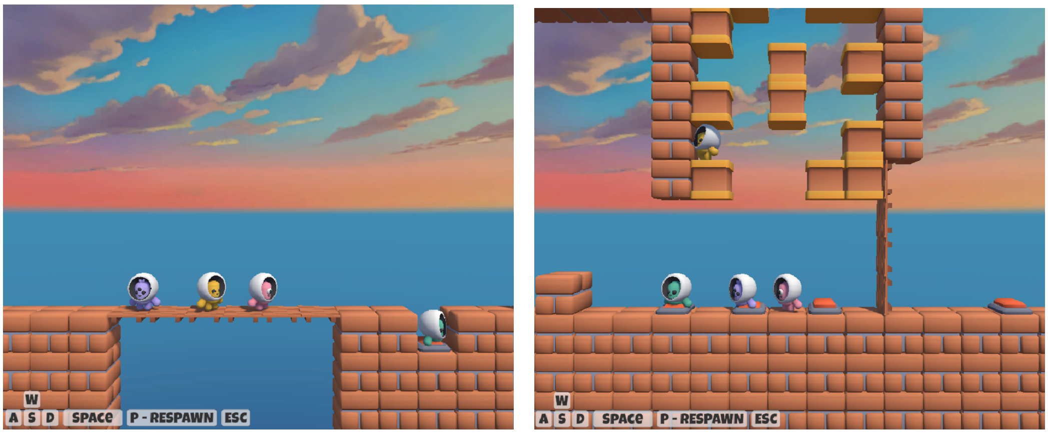


Figure 5.2: Level 1 layout for parts I, II and III.

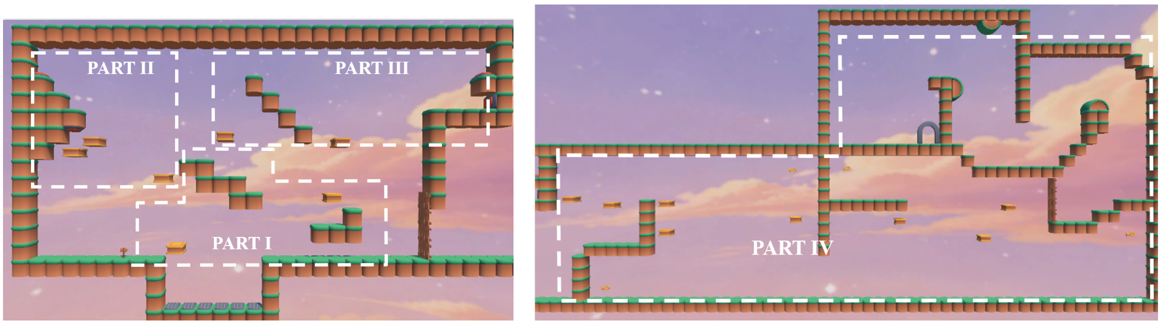


(a) Level 1 part I. **(b)** Level 1 part III.

Figure 5.3: Players work together to cross the bridge and climb the maze.

Table 5.1: Collaborative patterns identified in the first completed level

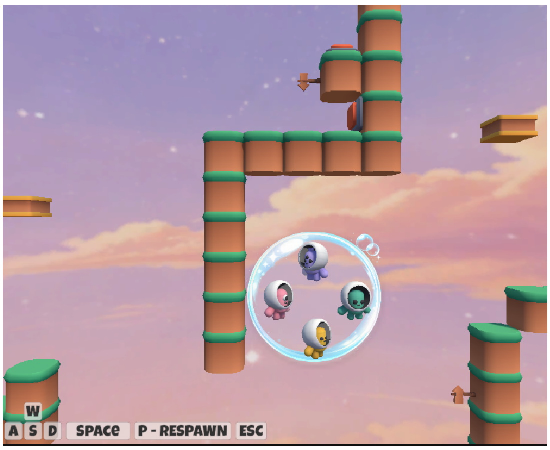
The first level completed for the game			
Parts	**I**	**II**	**III**
Description	Players must collaborate to cross a gap too wide for a single player.	A box must be moved to clear the path for all players.	One player navigates a puzzle where boxes appear/disappear based on others pressing buttons.
Patterns Included	Concurrency; Shared puzzles; Separation gate	Concurrency; Shared puzzles	Indirect actions; Concurrency; Shared puzzles; Encrypted information



(a) Level 2 layout for parts I, II and III. (b) Level 2 layout for parts IV.

Figure 5.4: Level 2 layout.

(a) Level 2 part II (b) Level 2 part III



(c) Level 2 part IV

Figure 5.5: Players work together to press the four buttons, and then navigate the bubble together.

Table 5.2: Collaborative patterns identified in the second completed level

The second level completed for the game				
Parts	**I**	**II**	**III**	**IV**
Description	Players must cross a gap using a moving platform.	All players must collaborate to reach two of four buttons traversing varying obstacles.	The remaining players must collaborate to reach the other two buttons.	The players must together steer a bubble, controlling one direction each.
Patterns Included	Concurrency	Shared puzzles; Concurrency; Separation gate; Gathering gate; Encrypted information	Shared puzzles; Concurrency; Separation gate; Gathering gate; Encrypted information	Complementary roles; Concurrency; Indirect action

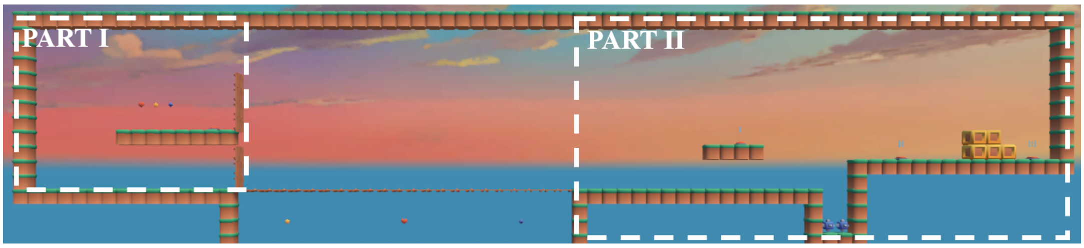
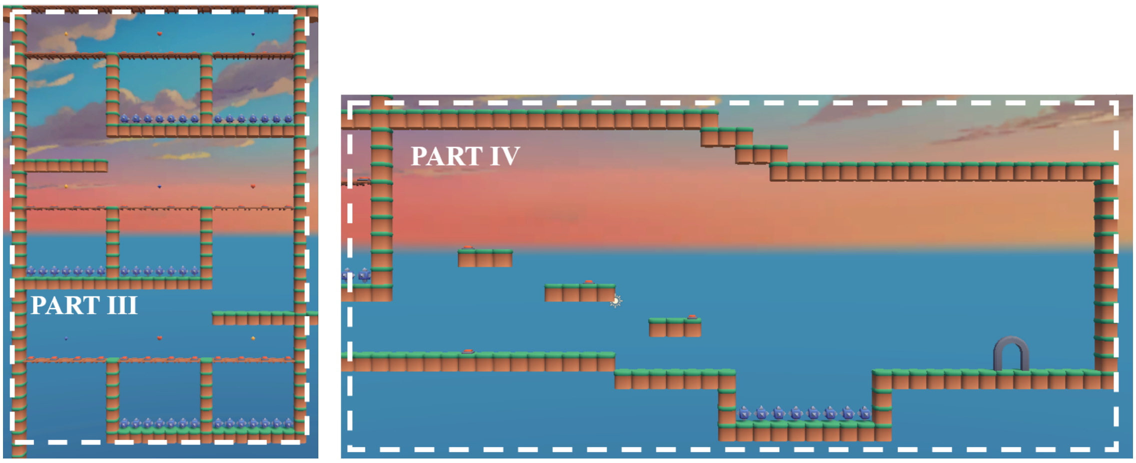


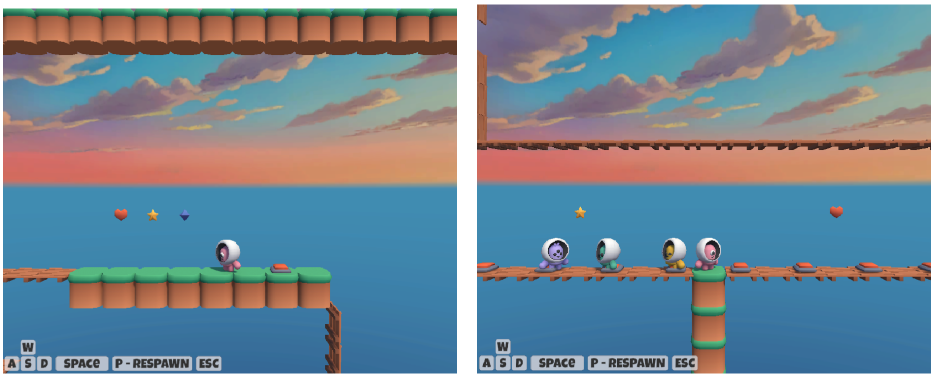
Figure 5.6: Level 3 layout for parts I and II.



(a) Level 3 layout for part III.

(b) Level 3 layout for part IV.

Figure 5.7: Level 3 layout for parts III and IV.



(a) Level 3 Part I (b) Level 3 Part III

Figure 5.8: Players solve the memory puzzle.

Table 5.3: Collaborative patterns identified in the third completed level

The third level completed for the game				
Parts	**I**	**II**	**III**	**IV**
Description	The group must help one player reach a platform.	The remaining players must traverse different obstacles to reach buttons, sending information to the player left behind.	Based on gathered information, all players must go down the correct path.	Players must help each other reach four different buttons.
Patterns Included	Concurrency; Shared puzzles	Concurrency; Separation gate; Encrypted information	Shared puzzle; Gathering gate; Indirect actions; Encrypted information	Concurrency; Shared puzzles; Separation gate

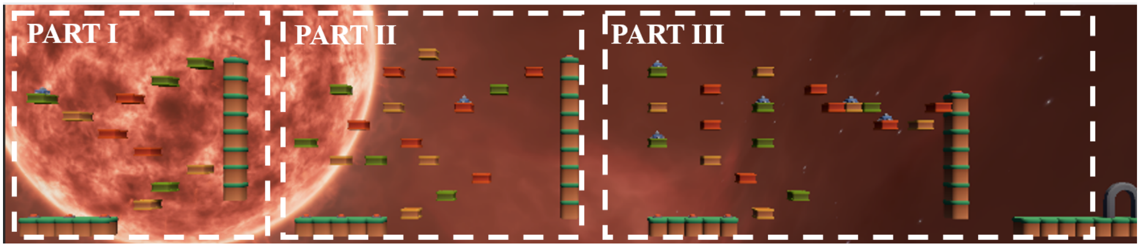
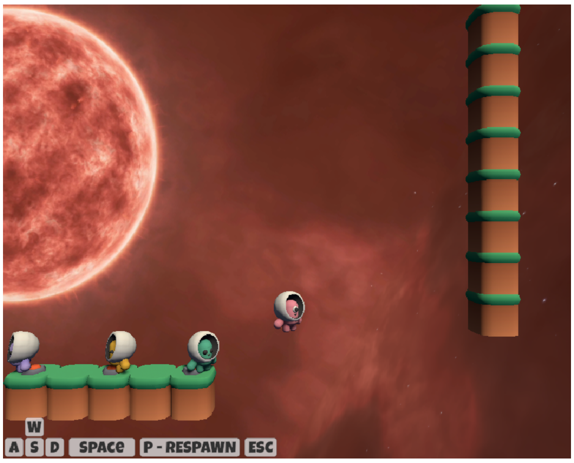
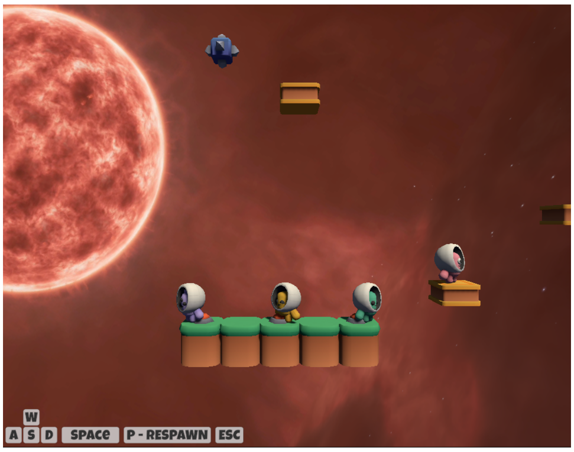


Figure 5.9: Level 4 layout for parts I, II and III.



(a) Level 4 Part I



(b) Level 4 Part I

Figure 5.10: Players work together by communicating what only they see to climb the maze.

Table 5.4: Collaborative patterns identified in the fourth completed level

The fourth level completed for the game			
Parts	**I**	**II**	**III**
Description	Players must together guide one player through an obstacle course using encrypted information.	Players must together guide one player through an obstacle course using encrypted information.	Players must together guide one player through an obstacle course using encrypted information.
Patterns Included	Indirect actions; Concurrency; Encrypted information; Separation gate	Indirect actions; Concurrency; Encrypted information; Separation gate	Indirect actions; Concurrency; Encrypted information; Separation gate

The CPMs for each part were mapped to their corresponding patterns, the sum was divided by the total occurrences of each pattern in order to more easily compare the patterns to each other. Bar graphs were used to visualize the data, where each CPM was mapped onto the X-axis and the prominence of the pattern was mapped onto the Y-axis. The graphs tell the reader which pattern gave what CPM responses and were made with the help of the compiled data shown in Appendix B. The calculated agreement percentage was only used as an indicator of annotation consistency and was not included in the final CPM calculations.

Figure 5.11 shows the results of the CPMs for the pattern *Concurrency*. The graph shows that the pattern was a catalyst for the CPM *Worked out strategies*, and *Laughter or excitement*. It gave no prominent result in the negative CPMs of *Waited for each other*, *Got in each other's way*, or *Blaming each other*. This could suggest that *Concurrency* was overall positive for collaboration.

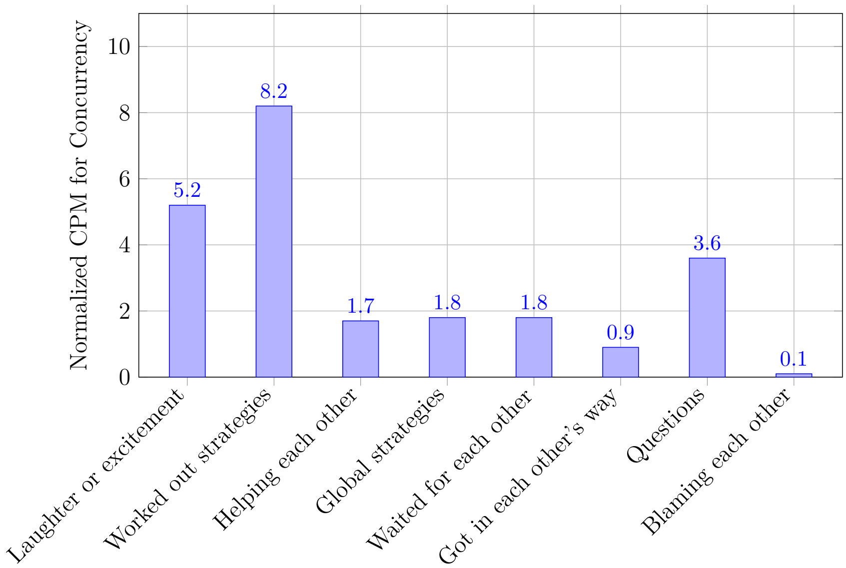


Figure 5.11: CPM behaviors across gameplay parts with *Concurrency*

Figure 5.12 shows the results for the pattern *Shared puzzles*. The figure shows overall similar results to the ones shown in the previous figure (5.11), mostly positive, although somewhat less in *Concurrency*, while maintaining the same number of negative events. This could mean that the pattern is slightly worse for collaboration.

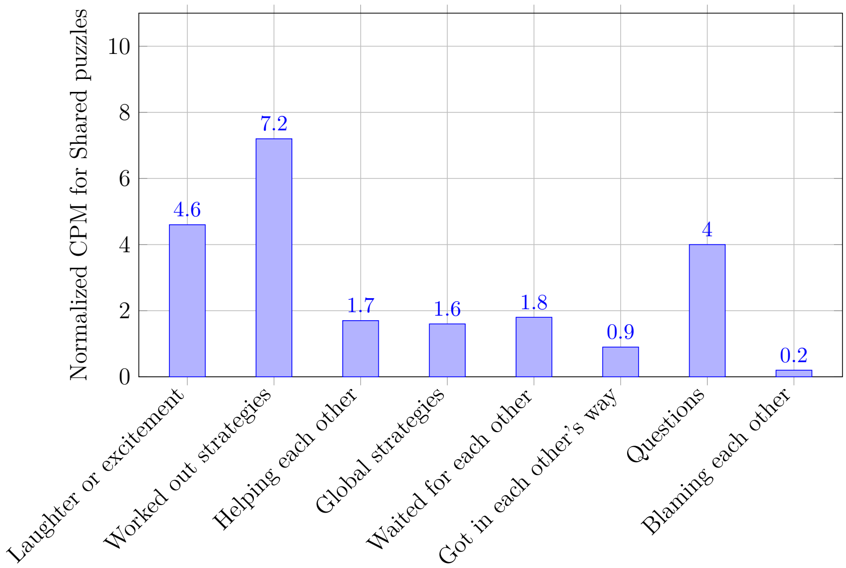


Figure 5.12: CPM behaviors across gameplay parts with *Shared puzzles*

Figure 5.13 shows the data collected for the *Separation gate* pattern. It is high in the positive patterns of *Laughter or excitement*, and *Worked out strategies*, peaking at a 9.5 in the latter, the third highest for that metric in this dataset. Overall, it shows low results for the negative CPMs suggesting that it is net positive for collaboration.

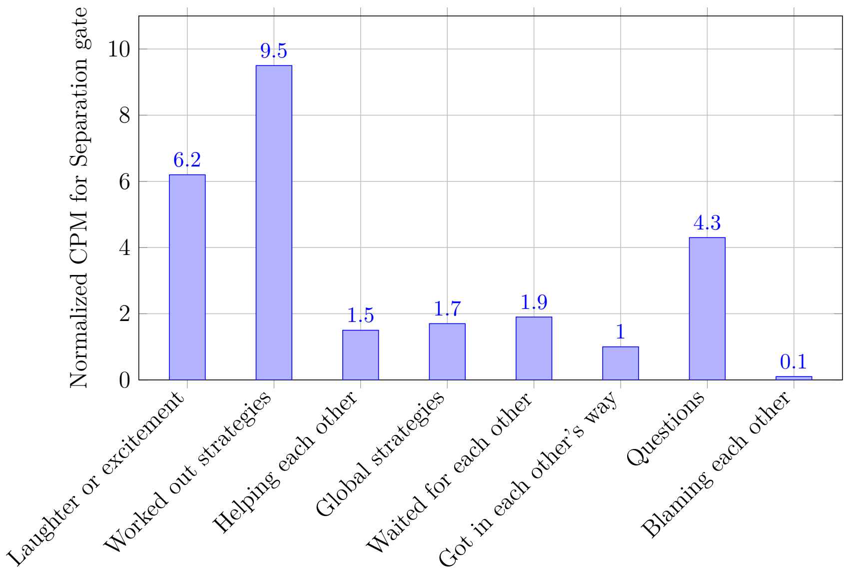


Figure 5.13: CPM behaviors across gameplay parts with *Separation gate*

The pattern *Gathering gate*, as shown in Figure 5.14, gave a higher score in the negative CPM *Waited for each other* than most patterns. This is to be expected since the pattern is meant to bring separated players together in one spot, meaning, some players will always have to wait on the rest. It gives an overall high result in the positive patterns, with above average results in *Helping each other*. Although it gave a larger result for the *Waited for each other* CPM, it gave a lower result on average in the negative category of *Got in each other's way*.

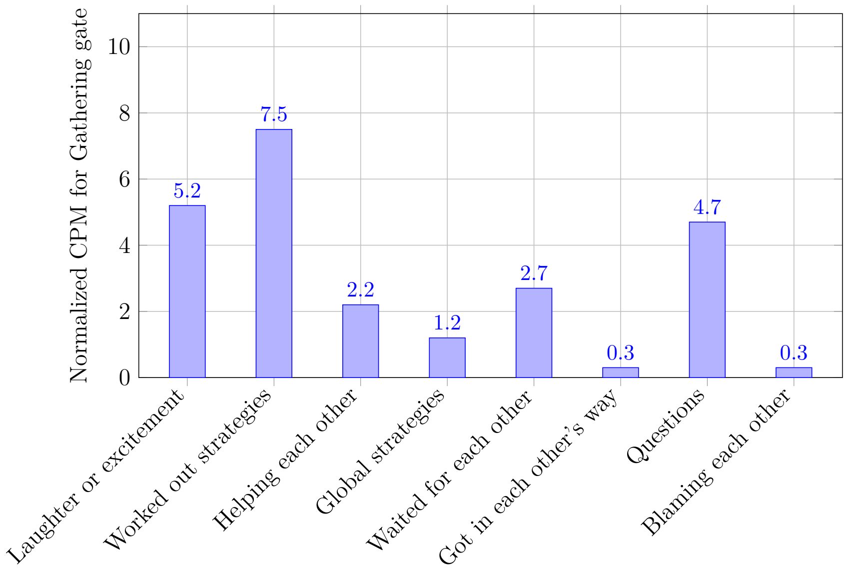


Figure 5.14: CPM behaviors across gameplay parts with *Gathering gate*

Figure 5.15 shows the data for the pattern *Encrypted information*. The figure suggests that the pattern is highly collaborative as it has given high results in the positive patterns, in particular *Worked out strategies*, which is the highest score in this dataset. The negative metric *Waited for each other* was higher than average, but the rest of the negative CPMs were about average.

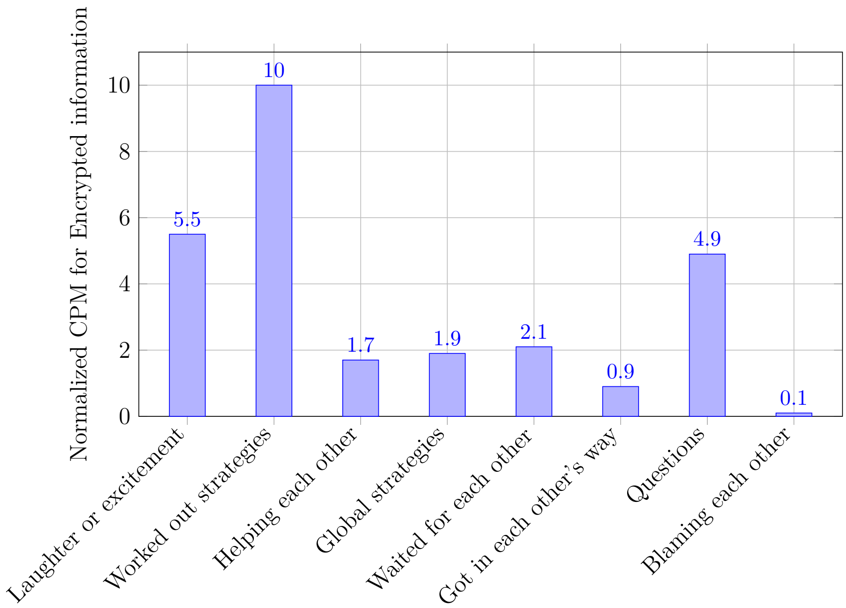


Figure 5.15: CPM behaviors across gameplay parts with *Encrypted information*

In Figure 5.16 the CPMs for the pattern *Indirect actions* are shown. Just as with *Encrypted information* (Figure 5.15), the results are overwhelmingly positive for collaboration. This is to be expected since *Indirect actions* are directly instantiated by *Encrypted information*, although with this patterns lower negative metrics were documented.

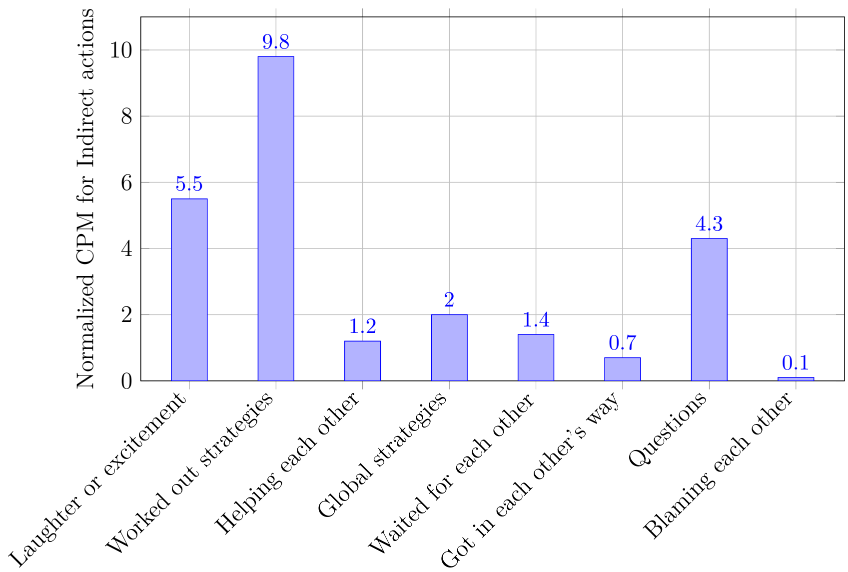


Figure 5.16: CPM behaviors across gameplay parts with *Indirect actions*

The pattern *Complementary roles* is presented in Figure 5.17, and show higher outcomes in both CPMs *Laughter or excitement* and *Worked out strategies*. Lower outcome is seen in the other metrics, and on a positive note, there are no instances of the negative CPMs *Got in each other's way* and *Blaming each other*. Worth to mention is that this pattern had a smaller dataset than the other patterns.

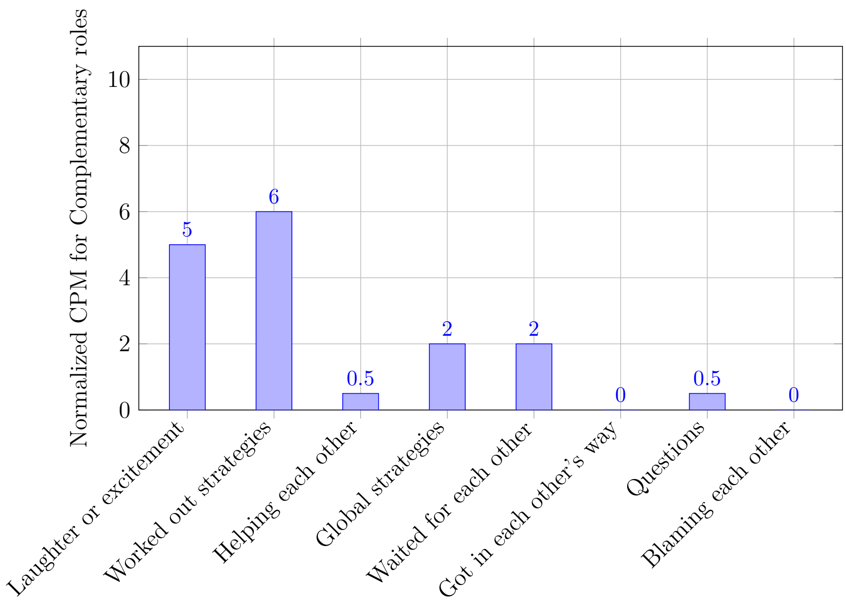


Figure 5.17: CPM behaviors across gameplay parts with *Complementary roles*

5.1 Survey

The survey was filled out by each individual playtester and therefore there are 20 responses. The scale used for the quantitative questions can be seen in Figure 5.18 and the distribution of the responses to each question can be seen in Figures 5.19 to 5.29.

In addition to these questions, most participants wrote additional feedback in the open-ended question. The majority of the feedback was on poor movement, with responses such as “Most irritation came from a bit too much acceleration at button presses...”, “Why do you jump so far?...”, and “Somewhat clunky controls...”. The fifth playtesting session generated quite a lot of feedback with possible improvements as it focused on the newest level, which had not undergone any iteration. Furthermore, comments were made about the game being fun and enjoyable, with responses including “Good first prototype! Fun with multiplayer...” (From the first playtesting session), “It was fun!”, “Super fun! Fun game!...”, “Very nice experience...”, and “Was fun!”. Additionally, a couple of responses complemented the visual aspects of the game, as seen, for example, in “The design is very cute” and “Cute design”.

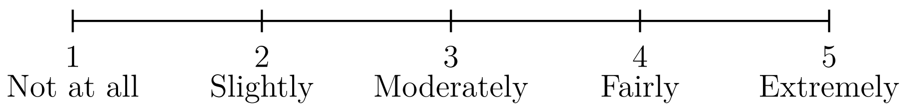


Figure 5.18: The scale used for the quantitative questions in the survey

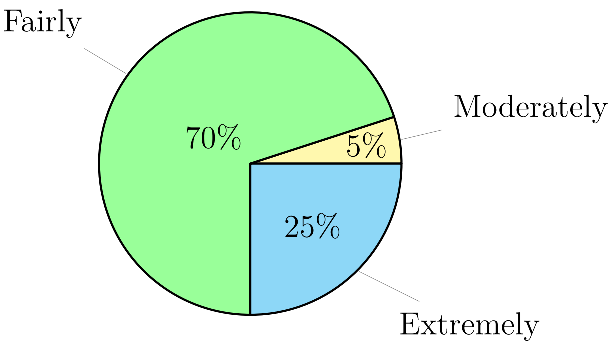


Figure 5.19: Pie Chart for question:
I thought it was fun

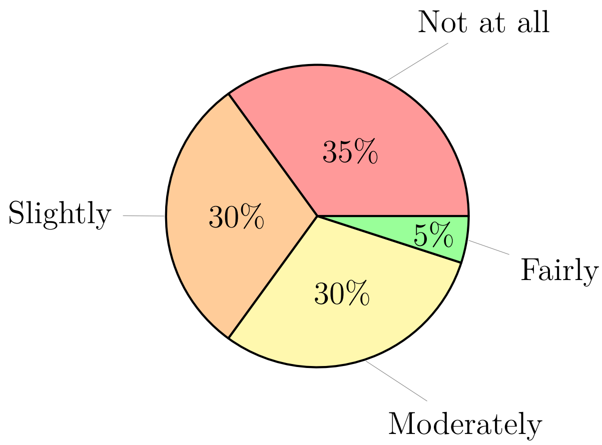


Figure 5.20: Pie Chart for question:
I felt irritable

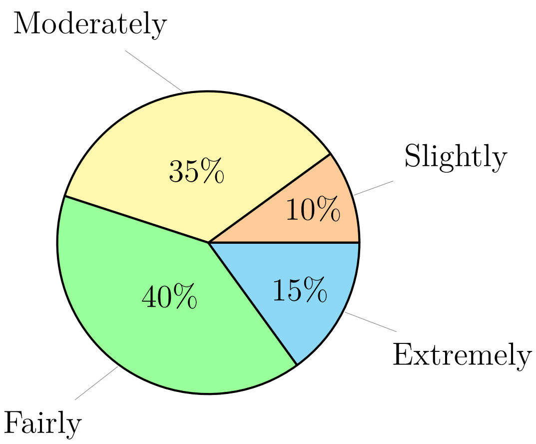


Figure 5.21: Pie Chart for question:
I felt challenged

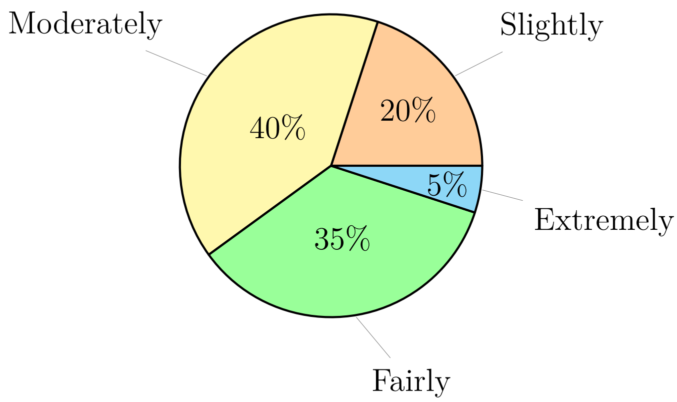


Figure 5.22: Pie Chart for question:
I felt that the controls were good

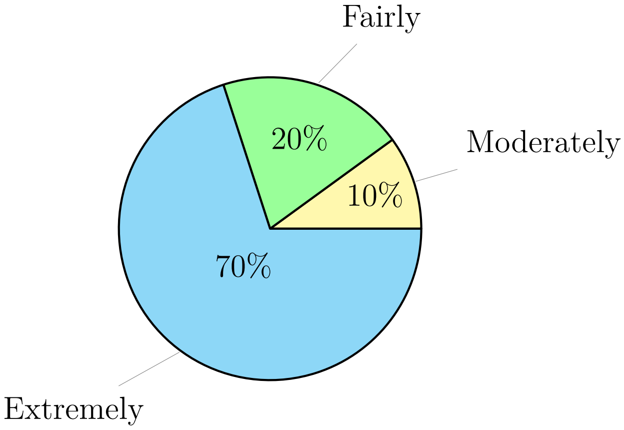


Figure 5.23: Pie Chart for question:
I found it enjoyable to be with others

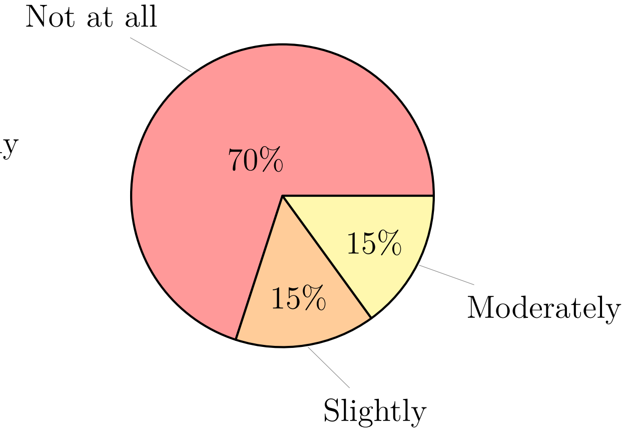


Figure 5.24: Pie Chart for question:
I felt revengeful

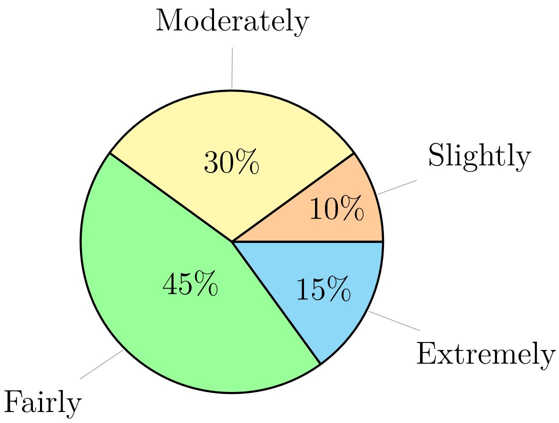


Figure 5.25: Pie Chart for question:
I felt connected to the others

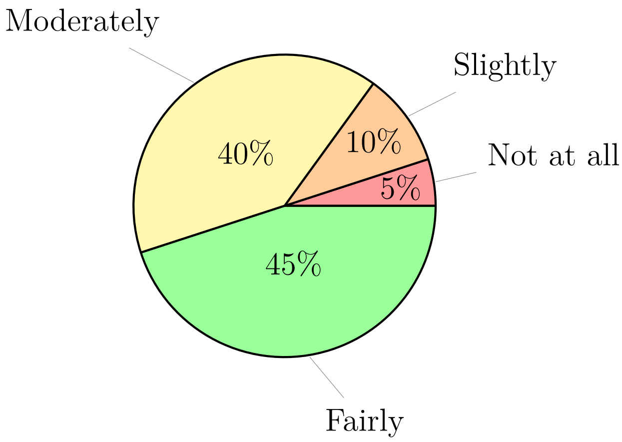


Figure 5.26: Pie Chart for question:
I paid close attention to the others

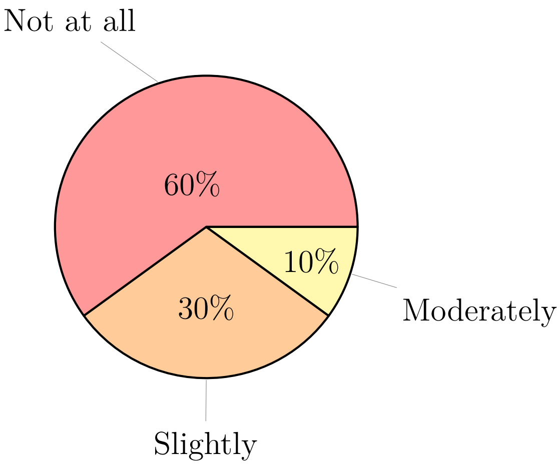


Figure 5.27: Pie Chart for question:
I felt jealous about the others

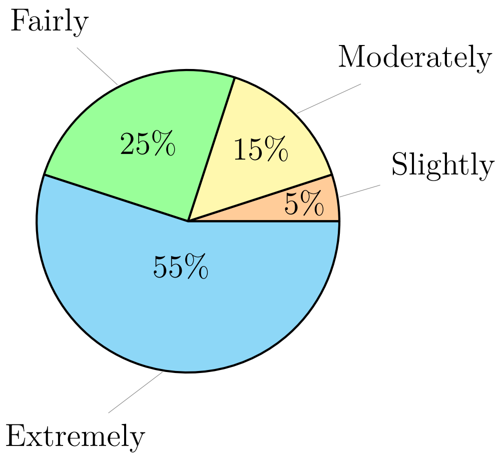


Figure 5.28: Pie Chart for question:
My action depended on the others actions

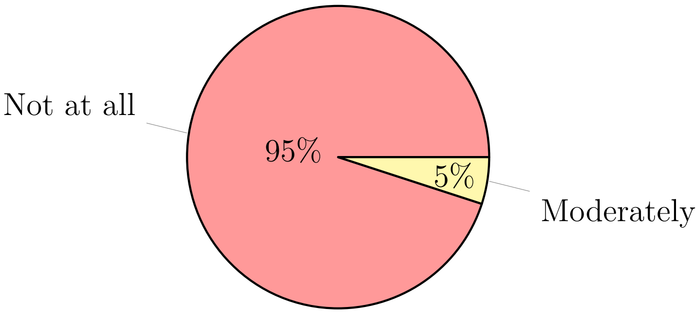


Figure 5.29: Pie Chart for question:
I found it a waste of time

6

Discussion

Observing the figures in the previous chapter we can highlight some key lessons and takeaways about how the different patterns impact collaboration. First, all the patterns analyzed in this report have a net positive contribution to collaboration, which supports the claims of the studies where the patterns were originally defined. The collection of patterns presented in the figures all follow a similar distribution in the results of the CPMs. *Laughter or excitement*, and *Questions* at a medium score; *Worked out strategies* the highest in each figure; the two remaining positive patterns at a medium-low; the negative *Waited for each other* at a medium-low; and the rest of the negative patterns at a low/virtually nil score. This similarity between the graphs *can* be interpreted as: a collaborative pattern will inherently result in more discussion among the players and a fun experience. But, the similarity of the graphs may also be due to the inherit limitations of the project and CPMs as a whole which will be discussed further in Retrospective and Limitations.

6.1 Game Design Patterns

Patterns concerning some kind of asymmetry of information among the players, i.e. *Encrypted information* and *Indirect actions*, have a highly positive impact on collaboration. This is especially noticeable in the *Worked out strategies* metric, since when not every player has the same information available, players must converse with each other in order to acquire a complete picture of the game state. Although these patterns are overwhelmingly positive for collaboration, a shared quirk in the data of these patterns is a higher result in the negative *Waited for each other* CPM, as stated earlier, this is to be expected since the gameplay overall will be slower when the goal is not straightforward and information has to be shared verbally between players.

Furthermore, patterns containing some aspect of determining where players are positioned in respect to each other, *Concurrency*, *Gathering gate*, and *Separation gate*, also gave highly positive results. The positive metrics gave similar, although on average lower, results than for *Encrypted information* and *Indirect actions*. This behavior is mimicked in the negative patterns, which also show lower results overall. This can be thought of as: *"these patterns are good for collaboration and bring a lower risk of bringing negative aspects into the game than the previously discussed* *patterns"*. The results for these patterns matches one's expectations, since giving players a separate position they must go to inherently opens up for discussion about who should go there, what they should do when they get there, among others.

The two outliers in the dataset are *Shared puzzles* and *Complementary roles*, as opposed to the other patterns, they both show a relatively lower result in the positive CPMs as well as a higher result in the negative one's. These results suggest that both of these patterns seem to be less important for collaboration than the others. However, this result does not mean that these patterns are bad for collaboration, as they still have an overall positive result. Furthermore, the results for *Complementary roles* should be taken with a grain of salt. This is because this pattern was only represented in one of the 13 parts analyzed for the game.

Overall, the data suggest that patterns that change the game in such a way that players must discuss either what they are seeing, where they should go, or what they must do lead to the most collaboration.

6.2 Retrospective

Because of the iterative method used during the development of the project, some parts of the method were refined during the process. For instance the way we playtested and collected data was changed several times. This meant that some of the sessions gave result that could not be used in the final analysis. This, and the fact that the project had a time limit of only 19 weeks, meant that the results, following discussion, and conclusion may not be of the standard that was first intended.

6.2.1 Method

In defining what game would be made the idea was to make a simple base, a platformer, where different Game Design Patterns could be applied to different levels in order to test them individually. This was done in order to ease the task of comparing different patterns. When performing the analysis, it was realized that many patterns were still overlapping and the original intent was diminished.

Due to the persistent network latency issue throughout the project and its iterations, the recorded data could have been affected. This latency made the base platforming more difficult than intended and the results of the CPM could be skewed towards *Laughter or excitement*, *Got in each others way*, and *Waited for each other*, since these three were the most common reactions of the players to e.g. falling down from a platform, or pushing another player into a spike filled hole.

6.2.2 Cooperative Performance Metrics

During this project, a decision was made to reuse the metric system invented by El-Nasr *et al.* [11]. This was done in order to be able to put more time into evaluating patterns instead of evaluating the method of measuring them. Sometime in the early stages of playtesting and annotating CPMs the group realized that one could get wildly different results based on who was responsible for annotating during the session. Because of this, the method for annotating had to be changed into a group task for more accurate data. Furthermore, the CPMs were expanded with two additional metrics in order to catch outliers that did not fit into any of the existing ones.

In addition to this, during playtesting, it was noticed that aspects of the game that the group deemed as highly collaborative did not give the expected result from the CPMs, or at least they were difficult to annotate. As an example, the game contained a level where the players would together be put into a bubble. Each player could only steer the bubble in one predefined direction. During play sessions, the group noticed that most playtesting groups would stop communicating, or communicate very little at this part, even though they collaboratively progressed in the level. This meant that this part would not give results on the metrics of: *Laughter or excitement*, *Worked out strategies*, nor *Helping each other out*.

Discussion was held within the group about how this could be remedied. It was hypothesized that since this puzzle was much easier than the others, not much communication was needed. The division of levels into parts for CPM annotation was done arbitrarily and adds additional complexity to the analysis. Some parts may have higher CPM counts because the puzzles are longer or more difficult.

This means that the CPM data may reflect puzzle complexity or time spent in a part rather than the effectiveness of the pattern. A possible solution would be to measure the time spent in each part and calculate CPMs relative to time, such as CPMs per minute. This could give another way of interpreting comparison between parts and reflect how the patterns affect collaboration.

Additionally, not all CPM categories may be equally relevant for measuring collaboration. For example, categories such as *Laughter or excitement* can occur for many different reasons unrelated to collaboration or Game Design Patterns. Players may laugh because of mistakes, unexpected events, or unrelated social interactions. Because of this, when analyzing and notating the CPMs some parts may not directly reflect collaborative gameplay and may need further interpretation instead of a count.

6.3 Survey

The survey provided valuable insights into playtesters overall perceptions of the game, as well as feedback in the shape of open-ended responses that complemented the group's own observations. However, the survey also presented certain limitations and areas for improvement, which may have affected the reliability and usefulness of the collected data. These aspects are discussed in the following sections.

6.3.1 Responses

The survey results indicate that players generally perceived the game as enjoyable, as a majority of responses leaned towards positive ratings on the question “I thought it was fun”, as seen in Figure 5.19 as well as in some open-ended responses. This suggests that the core gameplay concept was successful in engaging the players. While this was not the main purpose of the project, it was still helpful in collecting a better quantity and quality of data.

Responses to questions related more heavily towards collaboration also provided positive indications. For example, questions “I found it enjoyable to be with others” and “My action depended on the others actions” provided very positive responses, as seen in Figures 5.23 and 5.28. Two other questions in “I felt connected to the others” and “I paid close attention to the others” also leaned towards the positive side, as seen in Figures 5.25 and 5.26. These responses might indicate that the overall opinion of the game was that it is a collaborative one.

A recurring theme in the open-ended questions was the dissatisfaction with player movement, particularly regarding acceleration and jump distance. This was something the group was aware of during development and was later corrected, giving the players a more controlled feeling when playing, limiting the difficulty to the intended level and letting the players focus more on collaboration.

However, the sample size was relatively small, and responses may have been influenced by factors such as player familiarity with games or the social setting of the playtests. While the quantitative responses indicate generally positive player experiences, the qualitative feedback (open-ended responses) reveals more nuanced issues, particularly related to control and movement. This highlights the importance of combining both types of data to gain a more complete understanding of player experience.

Overall, the survey results suggest that while the game successfully encourages player engagement and collaboration, the movement mechanics limited the effectiveness of collaboration in practice.

6.3.2 Areas for improvement

When the questions for the survey were chosen, the group felt satisfied. Later, however, realization hit that it was more focused on game experience rather than actual collaborativeness (which arguably should have been obvious given the name: Game Experience Questionnaire). Perhaps more research should have been done to find a better fitting survey, focusing more on collaboration. On the other hand, there is an argument for having questions that do not focus solely on collaborativeness. This could be done to avoid “spoiling” the purpose of the study and the playtesting sessions, since the idea was to tell the playtesters as little information about the study as possible, to obtain pure data from it.

Another problem with the survey was that it was filled out after the entire playtesting session was finished, and not after each part or level. This means that the answers collected could not be pinpointed to certain parts of the levels or certain patterns, as it gave more general data about how enjoyable and collaborative the game itself felt. Since a major part of the purpose of the study was to evaluate which patterns facilitate collaboration with the highest efficiency, this means that the use of the survey could be deemed irrelevant for this study.

6.4 Limitations

The participants were volunteers with relatively similar backgrounds and levels of gaming experience, and the total number of participants was limited. This means that the results may not be representative of a wider player population. In addition, no control was made for whether participants already knew each other, which may have affected how they communicated and collaborated during the playtesting sessions.

The use of an unstructured playtesting approach allowed players to behave more naturally, but it also reduced control over the sessions, making comparisons between different groups more difficult. The presence of researchers during the sessions may also have influenced participant behavior through the observer effect, where individuals alter their behavior due to being aware that they are being observed [17].

Differences between game versions, such as bugs in earlier iterations and improvements in later ones, may have affected the consistency of the collected data across sessions. In some cases, interventions were also necessary, such as resolving technical issues, giving hints, or limiting the time spent on certain tasks.

The process of annotating and categorizing interactions using CPMs involved some level of subjective interpretation, which may have introduced bias into the analysis.

6.5 Future work

Further research into the use of CPMs may be valuable, as the results of this study suggest that CPMs may reflect more than only collaboration. During the analysis, it was observed that the longer time you spent on a certain part of a level and its puzzle difficulty, may also influence the amount of recorded CPMs.

This raises several questions for future studies. One possible area of research is whether CPMs could be used as a measurement of puzzle complexity and/or game pace. Difficult parts often resulted in increased communication, strategy discussions, and reactions between players, possibly due to the fact that they simply spent more time in that part of the level. While simpler parts generally produced fewer interactions. Because of this, CPMs may potentially be useful not only for evaluating collaboration, but also for balancing gameplay difficulty and pacing.

Future research could also investigate whether different target audiences produce different CPM distributions. Players with lower gaming experience may require simpler gameplay sections with lower communication demands, while more experienced players may engage more with complex collaborative mechanics and strategy discussions. This could potentially allow CPMs to be used as a tool for balancing collaborative gameplay experiences for different player groups.

7 Conclusion

This project set out to study the impact of several different Game Design Patterns on collaboration. This was done by developing a game, Pixel Pals, and collecting data from playtesting sessions. The created game is a four-player puzzle platformer with six levels, each with unique puzzles based on different patterns. The players must use collaboration to solve these puzzles and together reach the goal. The analysis was done using CPMs to measure the level of collaboration. The following patterns were looked at: *Concurrency*, *Complementary roles*, *Synergies between abilities*, *Shared puzzles*, *Separation gate*, *Gathering gate*, *Encrypted information*, *Indirect actions*, and *Shared resources*.

Our analysis suggests that the aforementioned patterns had an overall positive impact on the collaboration between the players. Patterns concerning asymmetry of information among players, e.g. *Encrypted information*, and *Indirect actions*, had an especially positive impact, while the patterns *Complementary roles*, and *Shared puzzles* had a slightly less positive outcome than the average.

The data collected in this project could be of use to game designers for the purpose of game creation or the balancing of existing games. One could create a level for a game with a target CPM in mind or use the patterns mentioned to ensure an overall collaborative experience.

Due to the discovered unfittingness of the CPMs used for the analysis in this project, the results found may not be sufficient for a complete conclusion. Our results point to that CPMs are intrinsically tied to the difficulty of the task given to the players, overall a more difficult task forced players to discuss the problem and therefore gave a higher score when calculating CPMs. The final analysis was done on a fairly small data set and may not reflect reality.

Pixel Pals promotes teamwork and communication by requiring players to collaborate, share responsibilities, and solve challenges together.

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A

Appendix

A.1 Survey Form

Playtesting Consent Form

Recording and Data Use By participating, you agree to the following:

1. Your gameplay session will be screen recorded.
2. You may be video recorded during the playtest.
3. Your responses to questionnaires or interviews may be used for research and development purposes.
4. Your feedback or recordings may be referenced or quoted in the project's final report or presentation.
5. Completing a short survey after the gamesession.

Data Protection (GDPR)

Personal data collected during this playtest (such as gameplay recordings, video recordings, and questionnaire responses) will be used solely for academic research and game development purposes. Data will be stored securely and retained for up to 6 months, after which it will be permanently deleted. Participation is voluntary, and you may request access to or deletion of your data at any time by contacting us.

By signing below, you confirm that:

- You have read and understood the information provided above.
- You voluntarily agree to participate in this playtesting session.
- You consent to the recording and use of your gameplay and feedback for research and development purposes.

Participant Name: ________________________________

Signature: ______________________________________

Date: __________________________

Email (to receive survey): ________________________________

B

Appendix

B.1 Level 1, Session 4

Table B.1: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	34	40	85.0%
II	16	18	88.9%
III	18	23	78.3%

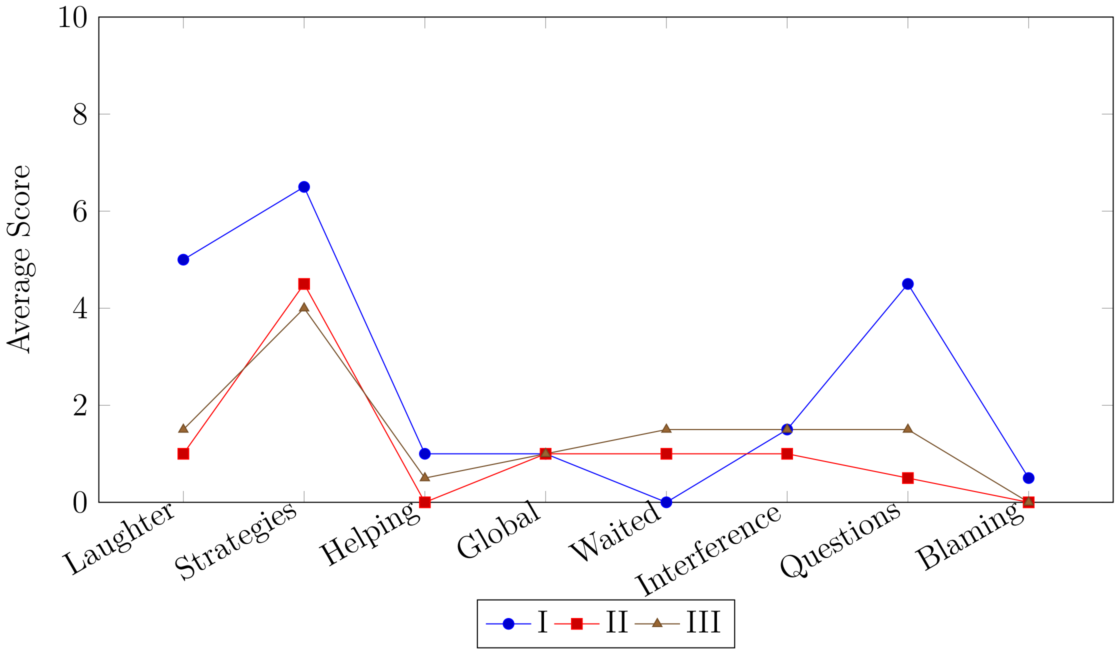

Figure B.1: CPM behaviors across gameplay parts

B.2 Level 2, Session 4

Table B.2: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	8	21	38.1%
II	26	37	70.3%
III	22	30	73.3%
IV	12	19	63.2%

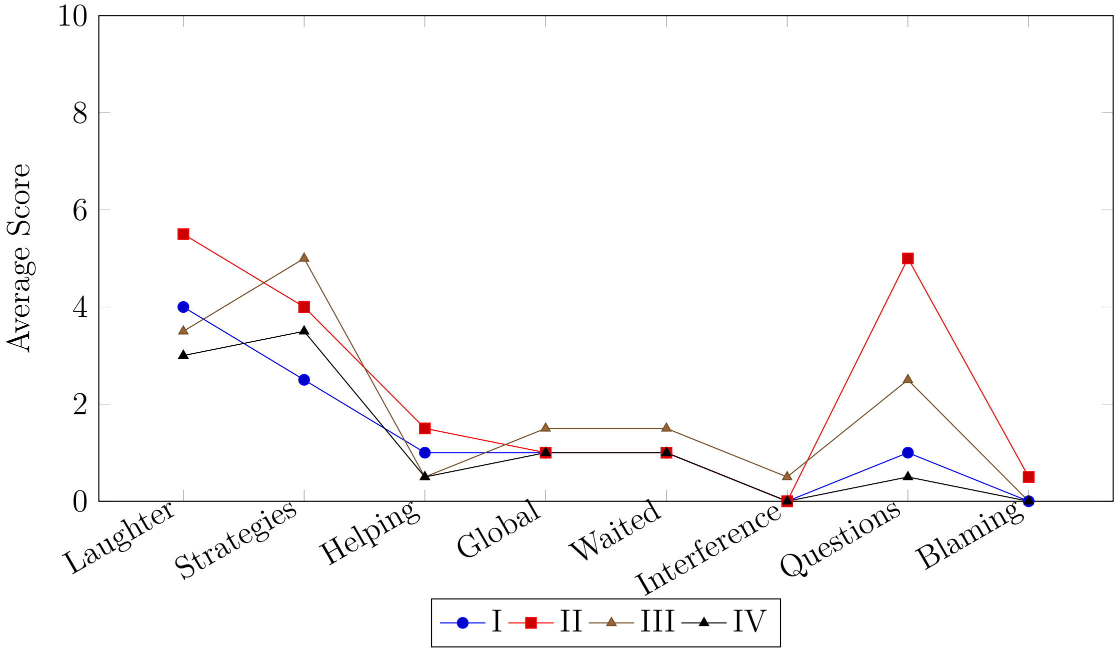

Figure B.2: CPM behaviors across gameplay parts

B.3 Level 3, Session 4

Table B.3: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	10	13	76.9%
II	20	32	62.5%
III	22	33	66.7%
IV	5	19	73.4%

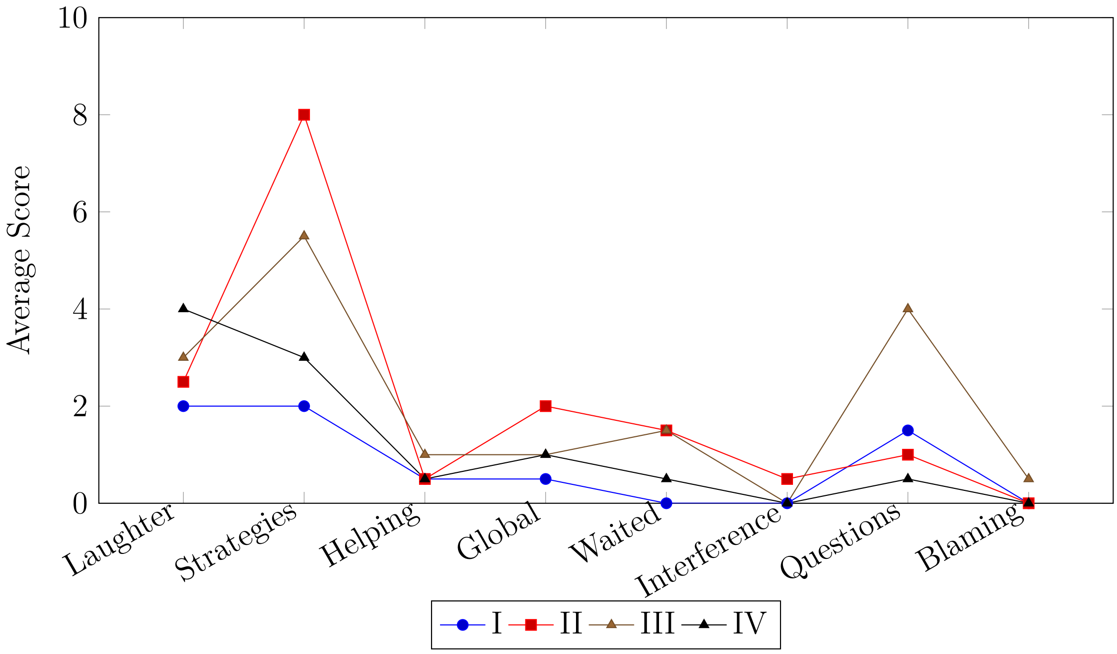

Figure B.3: CPM behaviors across gameplay parts

B.4 Level 4, Session 4

Table B.4: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	42	50	84%
II	14	20	70%
III	0	0	-

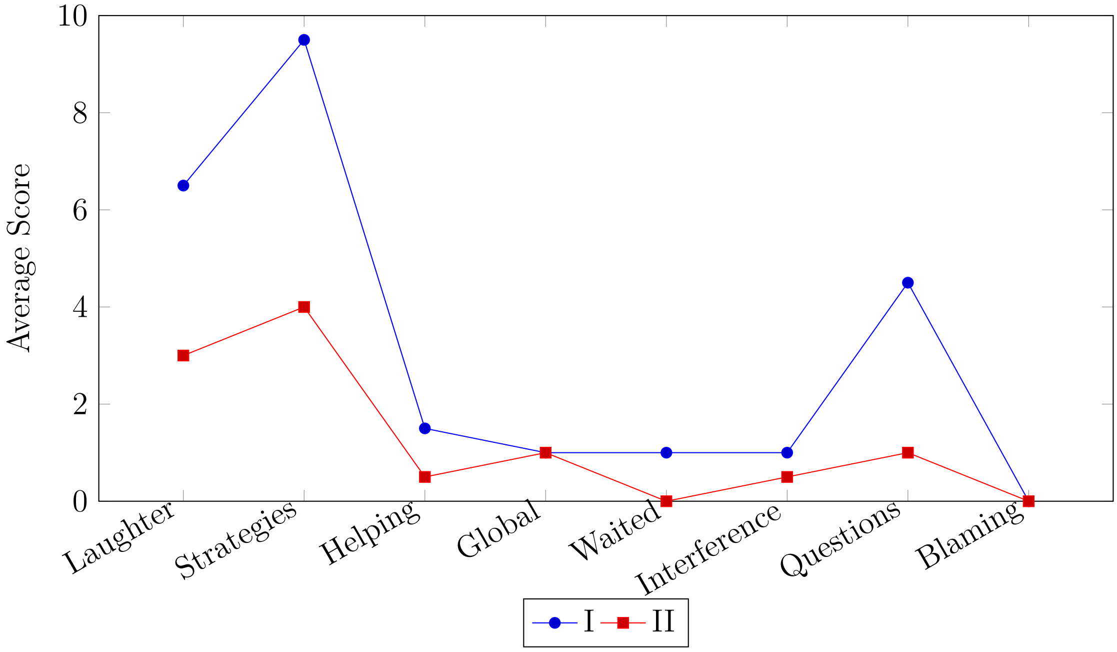

Figure B.4: CPM behaviors across gameplay parts. Note: The playtesting ended before part III started, it is not missed data.

B.5 Level 1, Session 2

Table B.5: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	14	21	66.7%
II	12	16	75%
III	26	33	78.8%

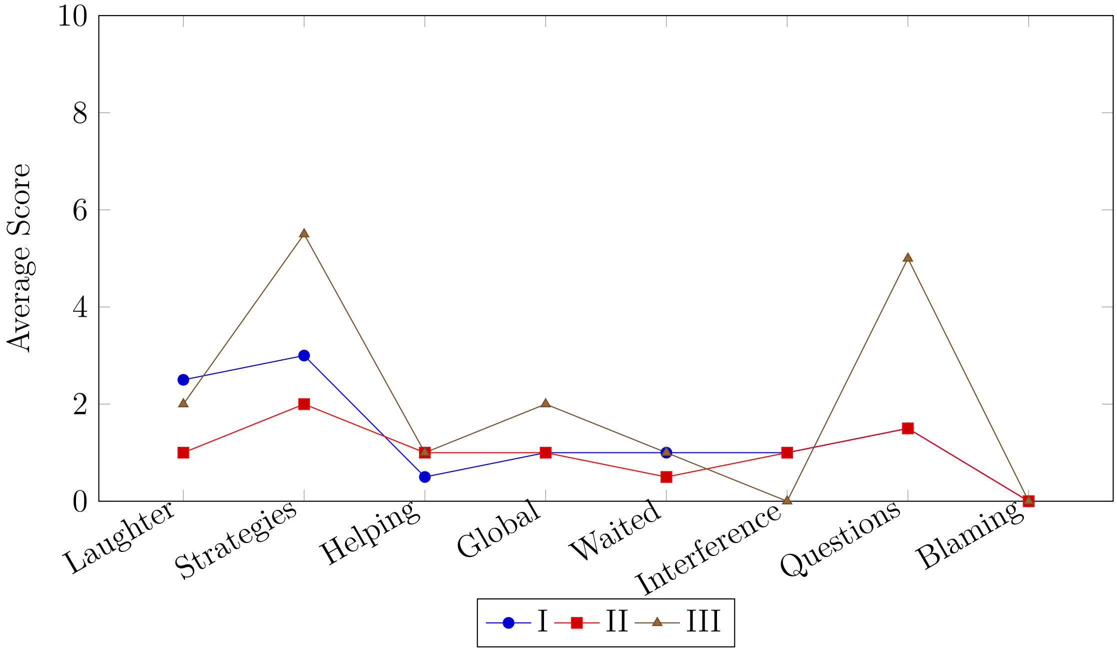

Figure B.5: CPM behaviors across gameplay parts

B.6 Level 2, Session 2

Table B.6: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	12	17	70.6%
II	8	22	63.6%
III	8	11	72.7%
IV	12	13	92.3%

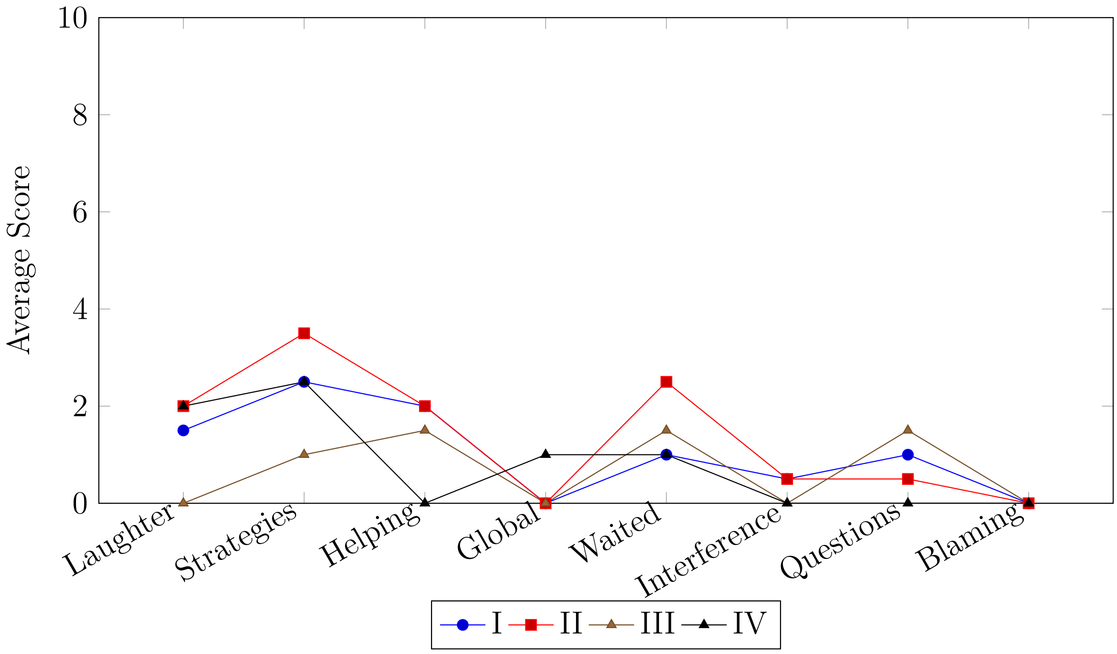

Figure B.6: CPM behaviors across gameplay parts

B.7 Level 3, Session 2

Table B.7: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	8	11	72.7%
II	24	31	77.4%
III	8	11	72.7%
IV	10	12	83.3%

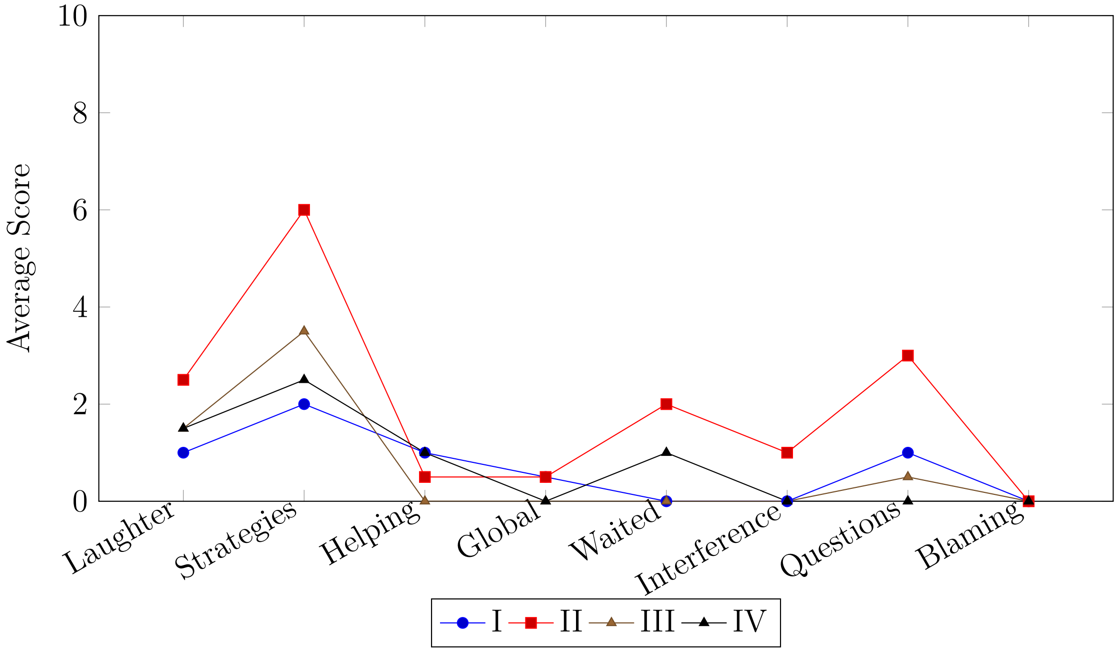

Figure B.7: CPM behaviors across gameplay parts

B.8 Level 4, Session 2

Table B.8: Reviewer agreement between observers

Part	Agreements	Total Observations	Agreement Percentage
I	27	33	84.8%
II	10	15	66.7%
III	6	8	75%

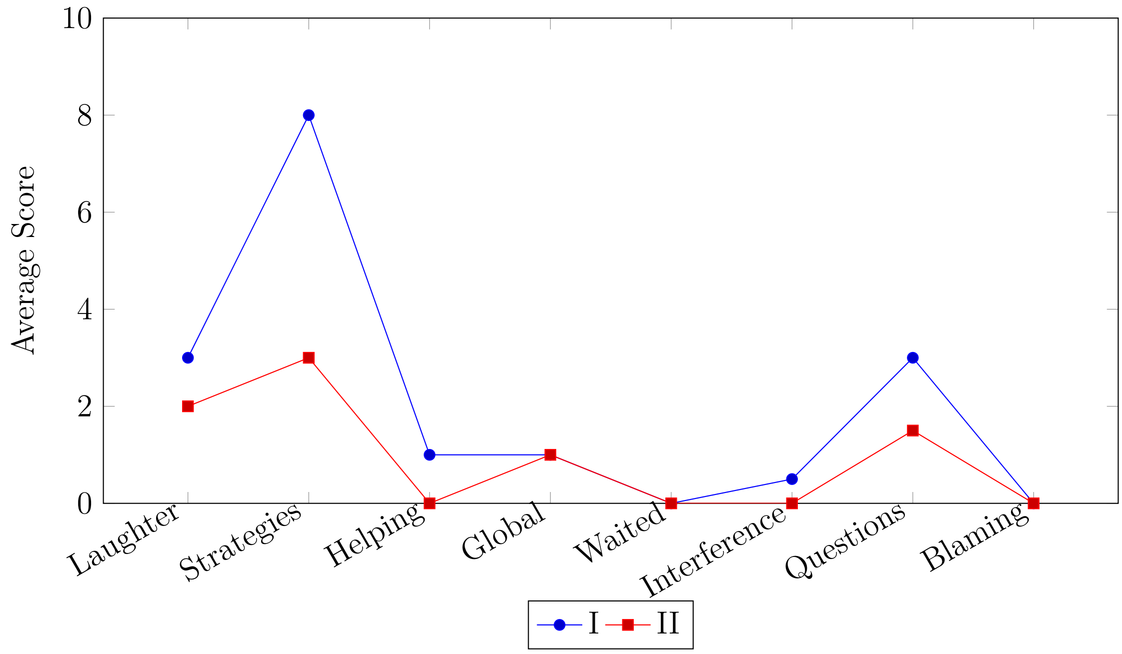

Figure B.8: CPM behaviors across gameplay parts. Note: The playtesting ended during part III, playtesters did not finish this part.