CHALMERS
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Escape Room Generator

Bachelor's thesis in Computer Science and Engineering

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Abstract

Escape rooms are real-life games where groups of players usually find themselves trapped in a room and must escape before time runs out. To achieve this, puzzles of various types must be solved, mainly through deductive reasoning or by discovery of hidden clues. They are conventionally considered a one-time experience, consequently offering little or no replayability. This thesis aims to provide a proof of concept for a generator capable of creating escape rooms. This would among other things, enable escape room companies to more easily create new escape rooms and therethrough give them the wherewithal to adjust their escape rooms to be accessible by most people, regardless of ability. Furthermore, the thesis describes the construction process of the generator and the decisions involved. User testing was done using two generated escape rooms structured in different ways. The results from these tests showed that the escape rooms were perceived as enjoyable although subject to biases. The generator achieves and exceeds the intentions set for the project. However, due to lack of testing, confirmation of whether an escape room creator is able to construct the puzzles involved in the generated room could not be concluded.

Keywords: escape rooms, generator, enjoyability, game design, accessibility, replayability

Sammandrag

“Escape room” är en gruppaktivitet där spelare oftast låses in i ett rum som de måste rymma ifrån innan tiden tar slut. För att ta sig ur rummet måste pussel lösas, huvudsakligen genom logiskt tänkande eller genom att hitta gömda ledtrådar. Dessa rum anses ofta vara engångsupplevelser, vilket leder till en brist på omspelbarhet (Eng. “replayability”). Denna uppsats syftar till att konstruera en generator som kan skapa “escape rooms”. Det här skulle bland annat underlätta för företag att skapa nya “escape rooms” och därigenom göra dem mer tillgängliga för dem flesta, oavsett funktionsvariation. Utöver det här kommer konstruktionen och designvalen bakom generatorn beskrivas. Användartestningen gjordes genom två genererade escape rooms med olika strukturer. Dessa tester visade att rummen ansågs “enjoyable” av deltagarna även om de delvis kan vara partiska. Generatorn uppnår och överträffar de syften som var uppsatta för projektet. På grund av bristande testning gick det inte att bekräfta huruvida “escape room” skapare kan konstruera det genererade rummet och dess medföljande pussel.

Nyckelord: escape rooms, generator, “enjoyability”, speldesign, tillgänglighet, omspelbarhet

Acknowledgements

Firstly, we wish to thank the participants who helped us with testing the quality of our product and also providing helpful feedback. Secondly, we would, of course, also like to extend a thank you to our supervisor Dr. Michael Heron for providing guidance and feedback on our development and ideas.

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Introduction

In this chapter, a brief background of the subject area of the thesis will be presented as well as the relevance, purpose, and delimitations of the project. In addition to this, the disposition of the thesis will be explained. This chapter aims to give context to the thesis topic and the project.

1.1 Background

The last ten years have seen escape room experiences grow into one of the more popular group activities of our time [1]. The idea behind them, solving puzzles with friends in a narrative experience, is both simple and intriguing. According to Nicholson [2], "Escape rooms are live-action team-based games where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal...". Most commonly this goal is to escape a locked room.

Escape rooms are usually played in teams of two to eight people. These rooms can take on many shapes and forms in terms of theme, narrative, and puzzle variety. With these different aspects of escape rooms, the possibility for variation is endless. This means that modelling and generalising escape rooms and their respective puzzles is far from trivial. Therefore, developing a generator for escape rooms is an interesting endeavor both from an academic and technical standpoint.

1.1.1 Brief History of Escape Rooms

The history of escape rooms lacks extensive and detailed documentation. This means that parts of the following overview cannot be academically authenticated.

One of the early influences behind the live-action genre of escape rooms, or "escape the room" as it is sometimes referred to, can be traced back to a video game called *Crimson Room* (2004) by Japanese game developer Toshimitsu Takagi [3]. However, some suggest that *Crimson Room* was the game that popularized the genre [4][5]. In spite of this disagreement of its origin, the escape room genre has influences as far back as *Behind closed doors* (1988), which was a text-only adventure game [3][4]. Contrary to *Behind closed doors*, *Crimson Room* was a simple "point-and-click adventure game" where the players explored the room they found themselves in. Puzzles in these games were usually based on finding items and attempting to use those items on objects in the room until the correct combination is found.

As time progressed and these virtual games evolved, their transfer into a real-world setting was explored. One of the earliest innovators of non-virtual escape rooms was SCRAP Entertainment, based in Japan. They opened their first live-action game called *Real Escape Game* in 2007 [2][6][7] and then continued expanding into the US market in 2012.

Since their first appearance in Asia and the west, the popularity of escape rooms has steadily increased [8]. Escape room establishments increasingly appear around the world, with different storylines, puzzles, and goals. As mentioned before, the original goal of an escape room was to find the exit in a locked room. Since then, escape room creators have moved on to new concepts and goals for players to achieve. Some of the concepts used in practice are:

- Collect money checks and get as high a score as possible [L1]
- Carry out an assassination [2]
- Free another person [2]

As of the writing of this thesis, the COVID-19 pandemic has impacted the escape room industry greatly, cultivating reluctance to meet with friends in an enclosed space. Despite this, escape room creators and maintainers have found new ways of bringing the escape room experience to prospective players. One example of this has been by going back to virtual options and better enabling the collaboration element missing from earlier escape room games through the use of multiplayer sessions [L2].

1.1.2 The Project's Relevance

There are many reasons why escape rooms are interesting from both a technical and academic perspective. One reason is its proven benefits in education, where it has been used to improve logical thinking, problem solving and motivation [9][10]. An example of this is *EscapeED*: a framework formalizing the creation of escape rooms [11]. In the paper, the authors achieve this by splitting the construction of escape rooms into six distinct steps determined for facilitating learning outcomes. This is significant, because a framework like *EscapeED* could be extended and even more generalized to provide other outcomes than learning. For example, a framework with enjoyability as its metric could be beneficial in escape rooms designed for the general public. Despite this possibility, there is no such framework as of the writing of this report, based on the project group's best knowledge.

Another reason the generation of instructions for an escape rooms could be considered interesting is its suitability as a modular application. In a non-modular system, adding a new puzzle would entail setting up the generator so that it knows the puzzle exists and how to handle it. For a generator with puzzles designed as encapsulated modules this would not be an issue. Every puzzle would be handled the same by the generator using polymorphism. Because of this, puzzles could be seamlessly added or discarded as time passes and the application is updated without developing the generator.

A generator built using a modular design would benefit the feasibility of expanding this proof of concept application into a larger system similar to the one described by Talliafero [12]. In this paper, the author thought it necessary to apply modular design as the system grows large. Without this, potential for improvements and the possibility to adapt when the purpose of the system changes is reduced. Moreover, the maintenance of the system will become increasingly difficult at a quicker rate than a modular system. In case the generator is deemed a success in its technical implementation and by feedback from user testing, being able to create a larger prototype will be necessary.

There are also stakeholders who could benefit from this generator. Creators of escape rooms would be able to spend more resources creating exciting stories for their rooms than before. This is due to the generator being able to give them the instructions for what puzzles and components are needed and how these interact, thereby drastically reducing the time needed for puzzle design. Such a scenario could reduce the cost of participating in escape room activities because of increased savings and higher margins for creators. This could in turn attract new creators increasing competition and pushing prices down for the consumer.

In addition to this, creating a generator would better enable the average person to access escape rooms. This is because the time investment that goes into constructing the puzzles and linking them together may be too high for casual events and those with busy schedules. Having a way to construct escape rooms in a more time effective manner would give these groups better access to escape room experiences.

1.2 Purpose

The main objective of this paper is to create an escape room generator as well as describe its construction. In addition to this, the generated escape rooms should be deemed enjoyable from the subjective view of the participants in the user testing. The proof of concept application will produce randomly generated variations of different puzzles and their associated relationships with each other. Using these, the user will be presented with an instruction encapsulating the multimodal information needed to construct the escape room. From these instructions, the user should be able to understand the following pieces of information:

- How to construct each individual puzzle in the room
- How the puzzles are connected to each other and how to link them together

Using their own resources, the user should then be able to construct a functioning real-life escape room based on the generated instructions.

1.3 Delimitations

The topic of generating an escape room is a task of generating a complex series of connected puzzles. Such a task is abstract, complex and time consuming and therefore some delimitation must be established to reduce the scope.

One delimitation will concern the physical installation of the generated escape rooms. Creating a generator that guarantees that every generated room is constructible in the physical world is simply too complex since an infinite number of factors are at play. Some examples of factors might be that the construction area has geometries or features unsuitable for certain puzzles or that electricity is not available at the construction site. Both cases and many more cannot be reasonably predicted. Therefore, this thesis will not guarantee that the physical installation is possible.

Another delimitation is generation of themed rooms or a told narrative. The generation of these would be extremely complex since the escape room generator would require certain custom formatting based on the design choices of how puzzles interact with each other. This in combination with the fact that narrative generation is still a largely unexplored subject [13] makes generated narratives a project in itself.

A traditional escape room usually has a *game master* that gives clues and aids the player's progression during the experience. Since the generator purpose it to construct puzzles and how they interact and not the physical aspect, it will not concern itself with the utilization of a game master or a digital equivalence.

Furthermore, escape rooms can be implemented in multiple different settings, and some of these settings will not be considered when the group develops the generator. More precisely, the generator will primarily focus on providing puzzles for conventional-type escape rooms. Board game-appropriate escape rooms will be a secondary focus. The settings that will not be focused on, includes convoluted multi-room escape rooms, video game-based escape rooms and other online non-conventional escape rooms. Multi-room escape rooms entails the complex mechanic where interconnected puzzles situated in different rooms exist, which might require that significant effort it put into designing the structure and experience. However, it should be noted that even though these escape room types will not be focused on, it does not mean that none of the solutions presented will work for those types, only that is not guaranteed.

Lastly, feedback from external stakeholders is also outside the scope. This is because it would not only entail a complicated endeavor to find and communicate with existing escape room companies, it would also reduce the time available for developing the generator itself.

1.4 Disposition

This thesis is divided into seven chapters: Chapter 1 serves to give the reader a brief background and an outline of the project. Chapter 2 explains the methods used in the different phases of the project. Chapter 3 lists the relevant research that impacted the project as a whole. The research includes literature, escape rooms and games. Chapter 4 covers the theoretical design of the generator. Chapter 5 sheds light on how development tools were used in this project. Chapter 6 covers the objective results that were produced. Finally, Chapter 7 explains the results of the project and ties back to the purpose.

This thesis includes both a traditional bibliography as well as a ludography. Citations belonging to the bibliography are cited with the IEEE standard, while the citations from the ludography are differentiated by the letter "L" in the citation.

In the end of the thesis, there are two appendices. Appendix A contains the raw data from user testing and Appendix B contains the visualization of this data in the form of graphs.

2

Method

This chapter presents the methodology used in this project. The presentation includes a description of the methods as well as the tools used, aiming to clarify why these methods were picked and what alternatives were brought into consideration.

2.1 Workflow

Throughout the entirety of the project, different workflow strategies were used to make sure progress was being made at a reasonable pace.

2.1.1 Scrum

Given the impact agile practices has had in the world of software development [14], working in an agile manner using Scrum to maximize efficiency and flexibility during the development process of the generator was considered a given by the group. The main idea behind the agile workflow is to be flexible regarding changes in requirements and priorities. This enables the team to regularly provide deliverable content. With Scrum, this workflow is partitioned into periods of time, usually one to four weeks, called sprints. A sprint begins with a planning phase where the work that will be done during the sprint is selected from a backlog of desired features for some product. The selection process adheres to the principle of prioritizing that which is deemed most important at the time. When the prioritized features has been selected for the sprint, the team starts working on all of the different items on the scrum board. At the end of a sprint, the team holds a meeting called a sprint review where the sprint is analyzed and discussed to see what lessons and improvements can be of use in future sprints.

For this project, individual scrum boards have been used to further extend the use of agile practices to encompass software development, research and writing. Maintenance of the backlog for each individual board has been handled by an appointed member of the group and overseen by the entire group at the regularly scheduled meetings. The plan has been to have sprints lasting approximately three weeks. The goals have been to allow the group to prioritize what is considered most important at any specific time, utilizing the flexibility of short iterations.

2.1.2 The MoSCoW Method

The MoSCoW method is a prioritization technique that aims to clarify which requirements of a project should be considered necessary, preferable, optional, and unwanted. The *M* in MoSCoW represent the requirements considered *Must have*, i.e necessary, the *S* represents the *Should have*, i.e preferable, the *C* represents the *Could have*, i.e optional, and the *W* represents the *Won't have*, i.e unwanted. This method was utilized extensively in conjunction with the Scrum workflow.

2.2 Tools and Technologies

When deciding on what core technical tools to use in the development of the generator, the main focus was to choose reliable modern tools that were widely supported and easy to become accustomed to. The reason for this was to bridge a knowledge gap between individual members of the thesis group, which could slow early development.

Assuming that parts of the design process could coincide with the implementation process, making sure that the core tools used allow for flexibility at a later stage in development is of utmost importance. If this flexibility is not considered, the software produced may have to go through major alterations or be less maintainable over time. Given that this project is not mainly about algorithms nor software design, the priority of the group has consistently been to embrace a working environment that lends itself well to ease of use and maintainability.

2.2.1 Java

The main sought after attributes when looking at a programming language is efficient handling of abstraction, extensibility and a high degree of familiarity within the group. These priorities were satisfied by Java and the language was thus quickly adopted as the primary programming language for the project.

One of the core strengths of Java is the ability to model real world objects as classes. Throughout the project, a great deal of time has gone into finding a useful model for a puzzle in an escape room environment. Such a model could then be encapsulated in a java class and described though attributes and behaviours, or fields and methods. Numerous components and associated properties of escape room puzzles can easily be modeled as individual independent classes in Java. Such items can range from concrete items, like clues, to more abstract properties, like a puzzle's level of accessibility. These components can then be used for constructing other more complex objects such as a super class for all puzzles in the generator. The object oriented aspect also contributes to how maintainable a Java application can be if designed properly. Each additional feature can be neatly encapsulated inside its own class, exposing only that which the author intended to be exposed. Finally, Java has existed for a long time and is still to this day one of the most popular programming languages [15]. In fact, all of the group members have had previous experience with Java. This legacy of the language brings with it a host

of valuable resources that makes it easy to find help with understanding the many features the language has to offer.

Other alternatives were considered in regard to what language to use for the back-end of the application. The idea of working in Haskell, a functional programming language, was discussed early on however was quickly neglected mainly due lack of experience working with the language within the group. JavaScript was also considered and seemed like a good choice given that it had already been decided by the group to host the application on a web server and use JavaScript for the front-end. However, the JavaScript code that was planned to be used for the front-end was predicted to be simple and constitute only a tiny portion of the application as a whole (mainly form validation and visuals). To successfully develop the generator itself in JavaScript a solid understanding of the language would have to be held by the entire group. The effort to attain such an understanding was considered unjustified given that the purpose of the project was not primarily related to software development. Instead, Java was chosen to minimize the time spent learning the tools as well as to maximize the utilization of prior knowledge and experience within group.

2.2.2 Spring Boot

To reduce the development time for logic not related to the generator and allow the application to be easily accessible for anyone, it was chosen to be developed as a web application. Thus, web frameworks compatible with Java were explored, one of these being Spring Boot.

Spring Boot is a solution for creating pre-configured Spring-based applications. Spring is an Open-source Java Framework, known for its use in enterprise applications. The advantage of using Spring Boot is that many repetitive tasks such as setting up a server, adding database support and communicating with a front-end through protocols is standardized. This standardization means that development can be focused on core logic such as the generation of escape rooms since much of the boilerplate functionality is already provided.

2.2.3 Web Server

To help keep a common frame of reference of what work on the generator was considered complete, a dedicated server was used to host the application. This allowed the group to always have a clear view of the project's state of development. The version deployed on the sever would be updated at the end of each sprint after the sprint review. This made it so that the latest complete and revised version of the application could be accessed at any time. The server did not only serve a purpose in helping the groups' efforts in working with the application itself, it also gave way for easier testing as all that was required to access the application in its current state was a simple uniform resource locator (URL).

2.3 Research

To cover as much ground as possible, an effective strategy was put into place for conducting background research. The idea was that a list of research was to be maintained by the group, serving as the common understanding of the thesis topic. The list would then be updated continuously throughout the project. The aim was to ensure that the majority of material originated from formal research. However, it is important to note that when it comes to research on escape rooms, it is not a particularly explored topic in formal research since it is a recently emerging field.

In formal research, we found there to be a gap in theoretical understanding of how escape rooms should be constructed. Significant research has been made in to escape rooms in the context of education [9][10][11]. However, theoretical understanding outside the context of maximizing learning outcomes is less explored. There is however formal research made in the field of game and puzzle design. If these theories translate into the context of escape rooms is still largely unknown.

These gaps led the project group to broaden the scope of used background material into non-academic contexts such as companies, conferences and journals. Moreover, judgement calls on qualities like reputability as well as industry relevance, had to be made by the group when deciding what material would be used.

2.4 Design

The goal of the methodology during the design phase was to enable the group to quickly device a clear picture of how the generator can accomplish its purpose (see section 1.2). This includes knowing what will be generated, what parameters should be included in that process, as well as what will not be generated (see section 1.3). Agile practices were used extensively in this design phase to handle potential changes of direction as the project progressed. This way of working was crucial given that the vision for what was to be created changed with each iteration of the generator.

2.5 Evaluation and User Testing

Two types of progression structures are used in the generator: a linear and a pyramid structure. The basic idea of a linear structure is that the puzzles in an escape room is completed in a consecutive fashion. The pyramid structure has its puzzles arranged in a tree-like structure where different dependencies of puzzles are set. A more detailed description of these structures can be found in section 4.2. Since there are two types of progression structures, two different escape rooms were orchestrated on campus of each type. Each room was played by one pair of participants at a time. Each room were run by a game master who provided hints to the participants if needed and would also act if any technical difficulties or issues would arise. The game master acted as the "wizard" as in "Wizard of Oz testing" [16], meaning that they would operate some parts of the escape room. Some parts of the clue distribution were done by a computer program that would take in a correct code

and return a clue for the next puzzle.

The participants were given 30 minutes each to complete the escape room. When the time ran out or the participants successfully completed the escape room, an interview was conducted. This interview was conducted to gather the participants thoughts on the experience as a whole, along with questions on the individual puzzles. The questions about the individual puzzles asked how difficult and how satisfying the participant felt each puzzle was.

3

Research

This chapter presents the research this project is based upon. It is divided into three sections, the first covers the relevant literature, the second covers the project groups experience with escape rooms and the third covers the board games and video games researched.

3.1 Literature

The following section covers the foundational research used for this project. It is a mixture of theoretical research on aspects concerning puzzle and escape room design as well as practical research on programming structure.

3.1.1 Enjoyability

A metric that could be used when rating escape rooms, and thus an escape room generator, is enjoyability. What enjoyability entails is highly subjective, since the motivation behind attempting an escape room varies between individuals. This can be everything from teambuilding to the thrill of solving complex puzzles under time pressure. This subjective nature makes the task of measuring or producing enjoyable experiences extremely difficult. Nevertheless, each escape room should try to maximize the enjoyability that each individual attempting it will experience. This holds true even if the purpose of playing the escape room is not to have fun, since by enjoying the task, individuals are more motivated and will have better focus [17]. This enables the motive to be achieved faster and more effortlessly.

Flow: The Psychology of Optimal Experience presents the theory of flow. When individuals' experience flow, the individuals only focus becomes the goal at hand with no regards for anything else. It is stated that "The most important trait of people who find flow even during adversity is non self conscious individualism, i.e. a strongly directed purpose that is not self seeking". Then theoretically, by creating escape rooms that can give individuals a "strongly directed purpose that is not self seeking" the enjoyability would be maximized [18].

Building on to this theory of flow is "GameFlow", a model presented in *GameFlow: A Model for Evaluation Player Enjoyment in Games*. It takes many of the accepted criteria from various authors for achieving flow and adjusts it to games. According to the paper, "GameFlow, consists of eight elements - concentration, challenge, skills,

control, clear goals, feedback, immersion, and social interaction." The conclusion of the paper was that this model could be used to review games [19]. Since a puzzle is a type of game and playing an escape room can be compared to a video game experience, it would be plausible to use part of this model to validate the generator's puzzles. This can be done through user testing to determine their individual enjoyability.

3.1.2 Progression Structures for Escape Rooms

The main idea of structuring an escape room is to create a collaborative, immersive setting where a group of people solve problems together. These puzzles are solved in an enclosed space and as the group progresses they get closer and closer to escaping from the room. It is common that as the group progresses, the puzzles become more and more challenging, exhibiting a difficulty curve [2][20]. Furthermore, the experience often follows a pattern of searching for clues followed by solving puzzles using these clues, thereby unlocking additional clues in the room.

One of the most common progression structures of escape rooms is a linear one (sometimes referred to as sequential) [2]. As implied by the name, a "linear escape room" is an escape room that consists of solving puzzles in a linear fashion, see Figure 3.1a.

Figure 3.1a: Illustration of a linear progression structure.

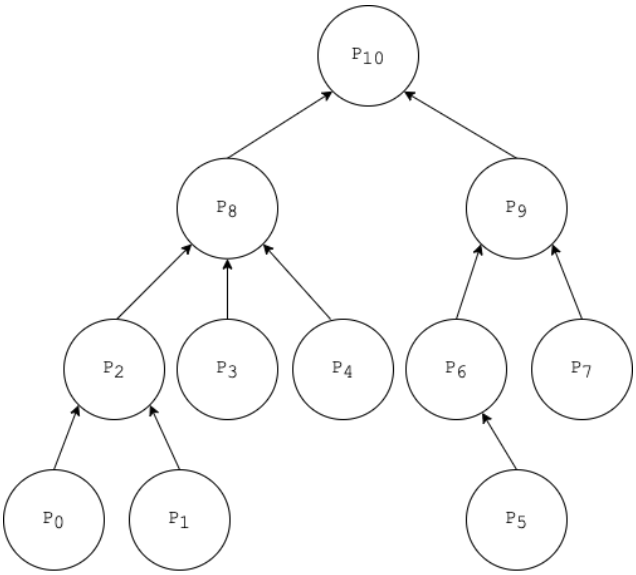


Figure 3.1b: Illustration of a pyramid progression structure.

Another structure incorporates the idea of having multiple puzzles that have to be solved to unlock the next puzzle. This idea is shown in Figure 3.1b; Puzzles P_2, P_3 and P_4 needs to be solved in order to unlock puzzle P_8. A natural deduction from this is that to unlock P_{10} (the meta puzzle) the players would need to have solved all the previous puzzles, $P_0, \ldots, P_9$, just like in the linear structure.

In addition to these structures, other more novel structures exists, each posing their unique opportunities and problems to a generator for escape rooms. One of these structures enables puzzles to give clues to multiple separate puzzles creating a structure resembling a directed acyclic graph (DAG), see Figure 3.2.

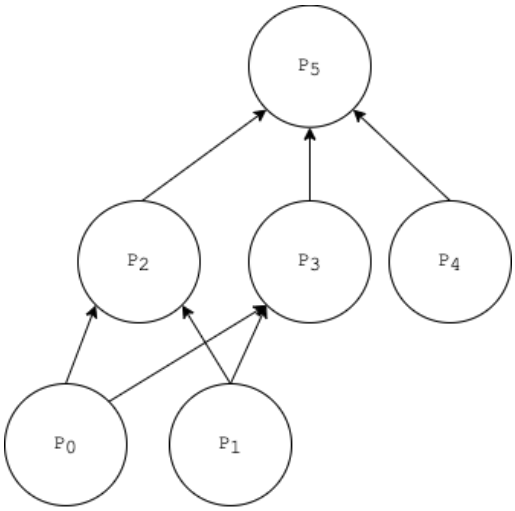


Figure 3.2: Illustration of a DAG progression structure.

Another possibility is having the required clues for a puzzle to be obtainable in multiple ways. This allows multiple different paths to solve the room, each with their own set of puzzles. This type of structure supports a key design concept: Making the participant's choices matter [8]. The structure would then serves to produce more engagement because every choice needs to be thought through.

3.1.3 Puzzle Design

Since the escape room generator will be creating puzzles, it is central to define how puzzles in escape rooms differ from "normal" puzzles, or rather, what aspects makes some puzzles better suited for escape rooms. The puzzles should be designed in a way that encourage different perspectives and reasoning, complimenting the purpose of a team activity. Furthermore, all the necessary items required to solve the puzzles should exist within each escape room, as to not require participants to bring tools to solve the puzzles [21].

When designing puzzles, it could be beneficial to separate them into different categories. This could serve several purposes; one would be to give an indication of the variety present in the generator. Using categories, issues with certain types of puzzles can be more easily spotted during user testing. These issues could then de-

termine what types of puzzles need modifications and which types of puzzle modules there should be more of.

Puzzles could be divided into two broad categories: mental and physical. The mental puzzles are based on logic and deductive reasoning while the physical puzzles are based on one's physical ability to move, reach or avoid objects to reach the goal [21]. Categories could also be divided into more, smaller categories, such as: Riddles, Hearing, Maze, Touch, Team communication and more [2].

Video Game Designer Schell recommends a handful of valuable guidelines for constructing puzzles that are enjoyable. These guidelines could potentially increase the enjoyability of the experiences when designing the puzzles for the generator. The following is the project group's interpretation of Schell's guidelines [22]:

- The goal of the puzzle should be easily understood. If players lack knowledge about the goal, the risk that they will avoid trying to solve it increases.
- It should be easy for the player to get started on solving the puzzle. In the case that it is perceived as too hard immediately, it risks being avoided as well.
- Give players a sense of progression. A lack of progression might lead to frustration while being able to visibly experience progression feels more satisfying.
- Give a sense of solvability. If the puzzle seems unsolvable, players will likely reconsider pursuing a solution.
- Difficulty should gradually be increased. Puzzles whose difficulty level remains the same could end up being uninteresting and mundane to solve.
- Parallelism should be implemented to let the player rest. When a player becomes stuck on one puzzle, the ability to move onto another until they are ready to reattempt it is beneficial.
- Usage of pyramid structured puzzles and providing hints can extend the interest of the player. Pyramid puzzles allow smaller puzzles to work as clues for larger puzzles and giving hints at the right time can stop players from giving up.
- Make sure to give the player the solutions in the end. The "Aha!" moment can feel very satisfying.
- Puzzles that require perceptual shifts are double-edged swords. Players that can observe the puzzle pattern in the required way may feel satisfied while those unable to will feel unsatisfied.

3.1.4 Modular Design

As the size of an application grows and time passes so does the number of issues that needs resolving. Different stakeholders have opinions about what strategy should be used to handle these issues. This concept can be summarized under the umbrella term technical debt. In the software industry, large amounts of time is invested managing the size of historic technical debt [23].

Even in proof of concept applications like the escape room generator that have a large possibility of being scrapped, minimizing this debt is important. This is since technical debt in the fundamental structure of the application would carry over to new prototypes. Thus, hampering the future development and evolution of the software if it were deemed successful.

One way to minimize technical debt and enable an application to scale and develop over time is by building it with modularity in mind. Modularity can be achieved by splitting the application into different distinct parts or modules that communicate with each other. How these modules communicate can be defined during the design phase of the application by modelling them as black boxes. A black box in this case can be seen as some module that has a defined number of input parameters set during initialization and a known set of request options for the outside to interact with. An example of this can be seen in Figure 3.3 where the two modules, Module 1 and Module 2, are interchangeable. This is due to them allowing the exact same request options. How this request is then handled is hidden inside each of the modules and is of no concern to the user.

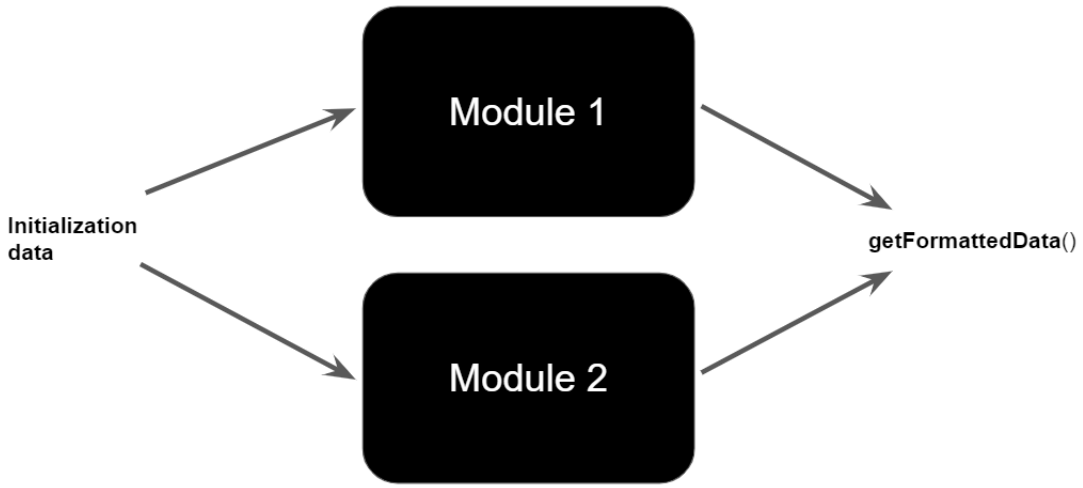


Figure 3.3: Figure of two black boxes that provide a common interface of interaction.

A generic property such as this gives the system many sought after qualities during the software life cycle. These qualities are flexibility, in case the needs of the system changes, reduced development time and a minimization of technical debt. These improvements have been seen in industry projects that changed their approach to focus more on the modularity aspect [12].

3.2 Escape Room Research

The following section cover the group's research into live-action escape rooms and Boda Borg. Important to note is that this research has a basis in the experience of the project group and could thus be subject to opinion.

3.2.1 The Asylum

The Asylum [L3] is a straightforward escape room with a relatively linear progression system and is one of the escape rooms offered by Escape House Göteborg. The setting is as follows; you and a group of friends have entered a mental hospital and gotten mistaken as patients. Now you must escape before Doctor E. Mendel arrives and lobotomizes you all. It consists of three separate rooms that one must go between to solve puzzles. Although this gives the impression of a dynamic and interactive escape room, the linear aspect hinders it. This due to the interactions between rooms being linear. However, by having a linear structure it ensures that the participating individuals usually knows what puzzle they should focus on.

The first puzzle that had to be solved was a cooperative puzzle that required two of the participants to hold hands for a current to pass through them that would unlock a set of cabinets. This cooperative part was a novelty for us. It was built in a way to ensure that at least two individuals had to participate to solve it. Although it might be difficult to create one puzzle module in the generator that could create different types of cooperative aspects, it would still be plausible to create one that could generate a puzzle based upon a single cooperative aspect.

Even though the cooperative puzzle was rewarding to solve, it probably was the hardest puzzle in the entire escape room. This in itself is not a problem, however since it was the first puzzle that had to be solved it could be demoralizing because of its high barrier to entry. Conversely, the last puzzle in the escape room was the easiest. Although it is hard to speculate on what the optimal order for the puzzles are according to their difficulties, it would not be unorthodox to think that in this case, a reversal of the first and last puzzle would have been a good idea. This would ensure that the participants right away would feel the excitement of solving a puzzle whilst still having to face a hard puzzle at the end to make them feel smart having solved it.

3.2.2 The Casino Heist

Similarly to *The Asylum* [L3], *The Casino Heist* [L1] is one of the escape rooms offered by Escape House Göteborg. The setting is as follows; you and a group of friends have infiltrated a casino with the objective to steal the entirety of the casino's money. The money is presented as checks that are hidden throughout the room, some of which can be found in plain sight and some that are locked in safes. After hearing the backstory, the group of individuals enter a small, enclosed office that is completely dark, and the clock starts.

As the goal of *The Casino Heist* [L1] is to find as much money as possible it differs from conventional escape rooms. Normally the objective is to escape from the room, or in some cases to achieve a singular goal. This escape room however does not have a clear goal of what clearing the room is. For some it might be to unlock the biggest vault, and for some it is to steal the majority of the money. This presented an intriguing idea, that an escape room can consist of several sub-goals instead on one singular one. Therefore, no matter how far a group can progress, they have always achieved some part of the escape room's goal. Furthermore, since it is next to impossible to find all the money, the groups can always stay in the escape room until the very last minute.

The aspect of sub-completion in escape rooms is an interesting concept. Although it gives every group a sense of completion, it also takes away the thrill and stress aspect of a timer ticking down in a room that one can either complete or fail. Depending on the group participating, this can either be for better or worse. This distinction presents the idea that the conventional escape rooms are not necessarily the optimal choice for every group. Although an interesting thought, the generator will not concern itself with different types of completion paths since it is outside the scope of this thesis. It would however be interesting for future research.

Lastly, *The Casino Heist* [L1] excel in its set-up. The first small dark room that led to an open casino-salon gave the perception that one genuinely broke into a casino. Even the puzzles incorporated its theme, with everything from hidden markers in a jacket to a thumbprint required to unlock a safe. It is crucial to point out that this was not necessary, as the puzzle could have been presented in a different way. However, this made the escape room feel more immersive and thus more enjoyable.

3.2.3 Boda Borg

Boda Borg is a company providing reality gaming experiences in their facilities around the world through a concept called Quests. The intended purpose of a Quest is to capture experiences found in movies, books or video games and actualize them in a single or several connected rooms in real-life. Several similarities exist between Boda Borg's Quests and escape rooms. Firstly, both typically contain puzzles that must be solved if the player is to progress further. Secondly, the experiences manifest in a contained environment where the ultimate goal regularly entails escaping that particular environment or fulfilling a certain criteria to emerge victorious.

One aspect that the Quests of Boda Borg could be criticized for is the potential absence of providing sufficient feedback to players when they attempt to complete critical tasks required to progress. Due to this, several puzzles where the players were supposed to interact with objects in the room in a specific way or order, would often lead to repetitive failures without an indication of what the players did wrong. As mentioned in the recommended guidelines of section 3.1.3, this inhibits not only the player's ability to clearly see the goal of the puzzle, it is also diminishes the sense of progression. This phenomenon highlighted the importance of designing puzzles to provide feedback and give visual hints as to how the player is expected to reach the solution, especially if they initially use an incorrect strategy.

3.3 Game Research

The following section covers the board games and video games researched. Their main purpose were to give inspiration for possible puzzles modules and to give an idea of how puzzles can be presented in different ways, and the consequences of these choices.

3.3.1 Mad Experiments: Escape Room

Mad Experiments: Escape Room [L4] is an indie adventure multiplayer game published and developed by PlayTogether Studio in 2020. The game tells a story about a scientist and his test subjects (the players). The test subjects must escape a series of rooms, where each room contains puzzles for the players to solve.

The game featured a few puzzles of interest. One of these puzzles used words and numbers that formed a pattern that the player had to figure out. In another puzzle, the players had to count the number of objects in a room to acquire a code. Both puzzles have the potential of being parameterised in order for it to be compatible with the generator.

3.3.2 The Talos Principle

The Talos Principle [L5] was published in 2014 by Devolver Digital and is a critically acclaimed narrative-based puzzle game that stretches the limits of what a puzzle entails. The protagonist is a robot that seems to possess a conscious mind that has to explore a world whilst tackling several philosophic questions regarding morality and reality. The goal of the game is to determine whether one should follow the will of Elohim (God) or to forge one's own path.

At first glance *The Talos Principle* [L5] is a simple puzzle game where one enters several different rooms to solve puzzles to progress. However, as the game progresses this linear way of entering one room, solving it and proceeding to the next breaks down and becomes more open. The puzzles become more intricate and encourages one to think outside to box to solve them. When this is realised the game can be seen in a different light as it can lead to hidden parts of the game and even different endings. This aspect of thinking outside the box when creating puzzles makes them both more enjoyable for the individual attempting them as well as rewarding when solving them. Furthermore, the whole game is driven through the heavy philosophical theme that makes the game interesting. Although theme is outside our scope it is important to realize its contribution to the immersion of the game.

3.3.3 EXIT

EXIT [L6] is a board game series revolving around the concept of providing an escape room in a box. In each game the players start with a limited amount of clue cards as well as a decoder disk. Throughout the game the players need to solve a

number of puzzles and use the decoding wheel to find the (correct) answer card. If all puzzles are solved within the time limit the game is won.

One of the big obstacles *EXIT* had to address was how to progress, and offer new clues and puzzles to the player without the locks, doors or boxes of physical escape rooms. *EXIT* addressed this using numbered riddles and answer cards, as well as a decoder wheel. The players must solve the puzzles to find a code, this code can then be decoded on the decoder wheel which gives the player a number corresponding to an answer card. This answer card then either redirects to the correct clues or tells the player that they're wrong. As a mechanic to stop excessive guesses *EXIT* punishes wrong guesses with removed time from the timer. *EXIT* makes it clear what the rewards for solving each puzzle is, and how these together form the clues for the next puzzle.

3.3.4 Unlock!

Similarly to *EXIT* [L6], *Unlock!* [L7] is a board game series focusing on escape rooms in a box. Like *EXIT*, *Unlock!* must address the issue of progression between different puzzles in a board game environment. *Unlock!* addresses this challenge through the usage of an app (see fig. 3.7), where codes can be entered and small interactive puzzles can be solved. This approach combines some aspects of digital escape rooms with board game escape rooms. Like *EXIT* wrong guesses result in a time penalty, to avoid too many guesses. However, unlike *EXIT* codes are not found using a decoder wheel, instead they are found using addition of two numbered clue cards. This method has a flaw: it allows for trial and error solving of puzzles, by matching all currently available red and blue cards with each other one can progress completely without understanding the puzzles. Like *EXIT, Unlock!* presents its clues and puzzles as numbered cards.

3.3.5 Indiana Jones And The Fate Of Atlantis

Indiana Jones And The Fate Of Atlantis [L8] was released in 1992 by LucasArts and is a critically acclaimed classic of the point-and-click adventure game genre. It features a story set in the Indiana Jones universe, where the player interacts with the world by selecting a verb representing an action, such as “Use”, “Give”, “Pick Up”, “Talk to”, and then selecting an object on the screen to carry out said action with. These actions are similar to those typically available to players in an escape room environment, which likely means the game contains relevant design choices.

Although the quantity of puzzles encountered in each section of the game was considered low in comparison to the other games explored throughout the project, how they employed the theme positively impacted the perceived quality of the experience. The game emphasizes the significance of theme when aiming to design high-quality experiences. However, adapting to a specific theme also adds complexity and could require significant effort to perform optimally.

Additionally, Fate of Atlantis features an interesting system for providing the player with hints. One of the non-player characters (NPC) that follows the player around

Figure 3.4: *EXIT*'s riddle, answer and help cards. As well as the decoder wheel.

Figure 3.5: One of *EXIT*'s environment pages, with the riddle card K visible.

Figure 3.6: The cards used by *Unlock!*, notice the hidden 18 in the red card, alluding that the card 18 can be turned over.

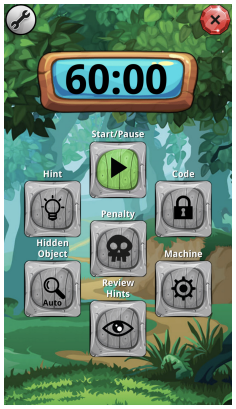


Figure 3.7: The app used by *Unlock!*, allowing players to find hints, enter codes and interact with "machines".

can be asked “What should we do now?”, to which the character often responds with “We should keep looking” if there are still interactions to attempt or objects to be found in the area, or “We should move on” if no actions or objects remain unexplored. Note that the hints are quite vague and does not give any specific information about what to use or where to look in the area to progress. This forces the player to find the solution on their own whilst still ensuring they do not end up searching the same area for non-existing clues or puzzles.

3.3.6 Sea of Thieves

Sea of Thieves [L9] is an action-adventure game was published in 2018 by Microsoft Studios. The purpose in *Sea of Thieves* [L9] is to become a legendary pirate by completing missions and adventures whilst defending your ship and loot from other players. To do this you have to solve puzzles, fight enemies, and navigate the open sea. Although the player versus player (PVP) aspect is a large part of the game, the player versus environment (PVE) aspect is where the game truly shines for a puzzle enthusiast.

Examples of these puzzles can be everything from solving riddles to find patterns in a treasure room. These puzzles can be challenging at first, however because of the limited puzzle variety the game it does not encourage replayability. However, the main adventures, although limited in number delivers handcrafted puzzles that are both unique and complex. The drawback of this is that they offer next to no replayability since the base design is always the same. To encourage some sort of replayability adventure missions vary in some way, for example to what island the player should go to, but the process of solving the puzzles remains the same.

3.3.7 The Witness

The Witness [L10] is a puzzle game published by Thekla, Inc. in 2016. The game takes place on a mysterious island containing many grid-like puzzles. Through non-verbal or written feedback from the puzzles, the player is able to identify new concepts and clues that will help them solve the puzzles. The concept of grid-like puzzle is utilised and innovated upon in great lengths in *The Witness* [L10] adding small, but significant variations for each puzzle.

The game contains very few gameplay mechanics, so by altering each puzzle a little bit allows for extensive replayability. This also contributes to the reduced need for the player to learn new mechanics, thus making the puzzles more rewarding. Given the potential for parameterisation in the puzzles introduced in *The Witness* [L10], they could be easily utilized in a generator.

4

Design

This chapter delves into the design of the generator. What design choices were made will be explained and motivated. This chapter aims to give the reader a conceptional understanding of the design, while Chapter 5 provides a description of the practical implementation.

4.1 Puzzle Modules

The quality of an escape room is partly dependent on its variety and creativeness in puzzles. Thus, the generator was designed with modularity in mind. This modularity is seen in the design of the puzzle modules. These modules are designed to be black boxes interacted with by the generator through a common interface in accordance to modular design explained in section 3.1.4. This mode of interaction guarantees that modules which follow the common rules for interacting with the outside seamlessly integrate with the generator. Thanks to this decoupling, modules can also be dynamically substituted, chosen, or removed during the generation stage.

The generator's modules represent distinct puzzles available for the generator to use when creating the escape rooms. Furthermore, each puzzle requires a different strategy to be solved and contains elements that are randomly generated to create a varied experience even when attempting modules of the same type.

Key code Puzzle

The design of the key code puzzle is fairly simple. A code in the room is discovered by the player and entered on a keypad installed in the same room. While simple, the benefit is that it easily can be used as an adapter between two puzzles since most puzzle rewards can be translated into a set of numbers or symbols, which then serve as a clue to a second puzzle. Another benefit is how adaptable and easily it can fit the narrative or setting of a room since this type of puzzle fits all escape rooms with a modern theme.

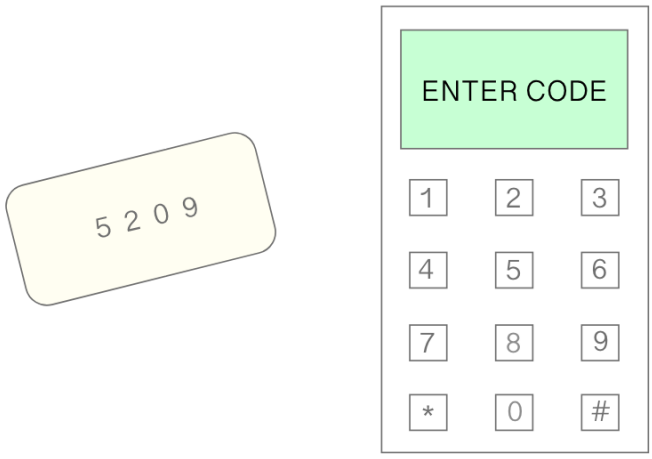


Figure 4.1: Concept sketch of key code puzzle.

Key Puzzle

The key puzzle shares several characteristics with the keycode puzzle. Solving it is not a challenging task, however it connects well to other puzzles and represents the classic "Find the key, open the door" type of challenge. Like the previously mentioned key code, the key can take on whichever form is deemed most suitable for the specific Escape Room.

Figure 4.2: Concept sketch of key puzzle.

Assemble Picture Puzzle

Assemble Picture Puzzle is akin to the jigsaw puzzles of old, where the player must construct a complete image using a set of pieces that fit together. For this implementation, the completed image provides a code, which as explained before is conveniently used as a clue for another puzzle.

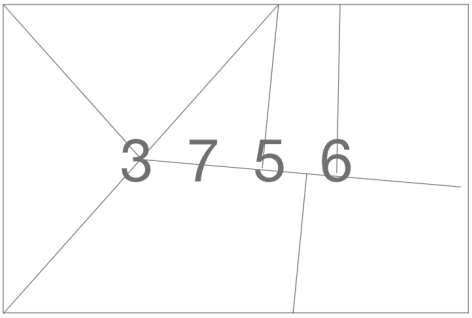


Figure 4.3: Concept sketch of assemble picture puzzle.

Chess Puzzle

There were several ideas as to how a puzzle involving a chess board and its pieces could provide a clue or reward. One possibility was having the players make a set of moves, ultimately placing a theoretical opponent in a state of checkmate. In that case the moves would represent a solution. While that would be an interesting mechanic, the implementation of such a puzzle would be quite difficult. This is since there is no simple algorithm to construct chess positions where you are a certain number of moves from checkmate. Due to this issue, the puzzle was re-designed so that it only required the player to visually observe a set of pieces positions and use their collective positions to form a code.

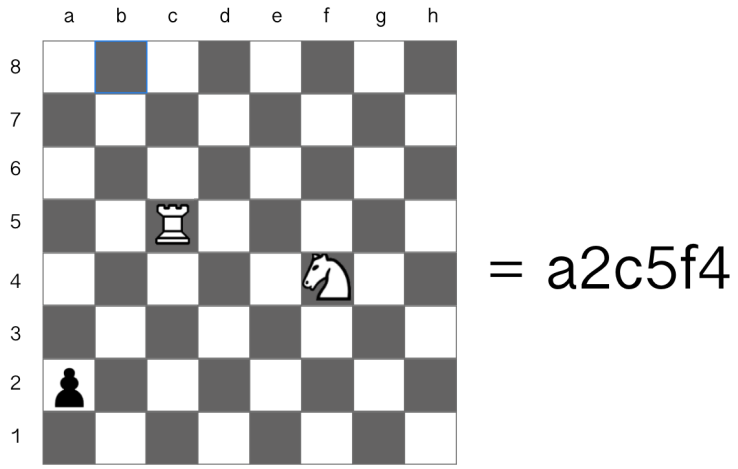


Figure 4.4: Concept sketch of chess puzzle.

Mirror Number

This puzzle involves translating what at first seem to be arbitrary symbols into a code. In actuality, the symbols were constructed by mirroring two numbers and placing them next to each other, sometimes with some overlap to increase difficulty. This is then repeated an arbitrary number of times with each number mirrored producing one character of the code.

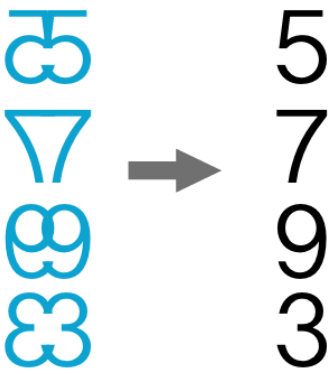


Figure 4.5: Concept sketch of mirror number puzzle.

Mastermind

The mastermind puzzle is based on the board game classic that involves guessing a combination of numbers. Usually it requires two actors, one who chooses the combination and one who guesses the combination and uses colored objects instead of numbers. The implementation used by the generator provides pre-determined guesses to the player, replacing an actor with which the player would normally interact with. This reduces the complexity of realizing the puzzle for the application user, while maintaining the core rules of mastermind.

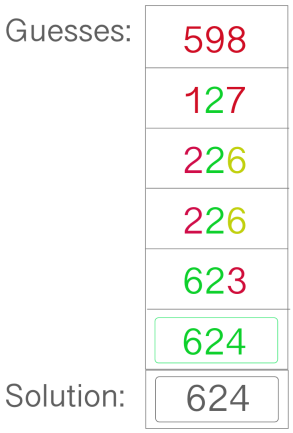


Figure 4.6: Concept sketch of mastermind puzzle.

Zodiac

The Zodiac puzzle involves several components: zodiac signs, cardinal directions, a compass, and riddles. The player is supposed to figure out which zodiac signs to draw a set of lines between inside an octagon. The edges of the shape represent cardinal directions and through the usage of a set of zodiac signs a player has to figure out in what order to draw the lines. The order of cardinals can be derived from riddles found in the room. Seemingly the most complex puzzle the generator offers, it is expected that this puzzle is mostly suitable in the last stages of an escape room experience, to ensure that the suggested difficulty increase mentioned in section 3.1.3 occurs. The inspiration from this puzzle came from *Sea of Thieves* (see section 3.3.6).

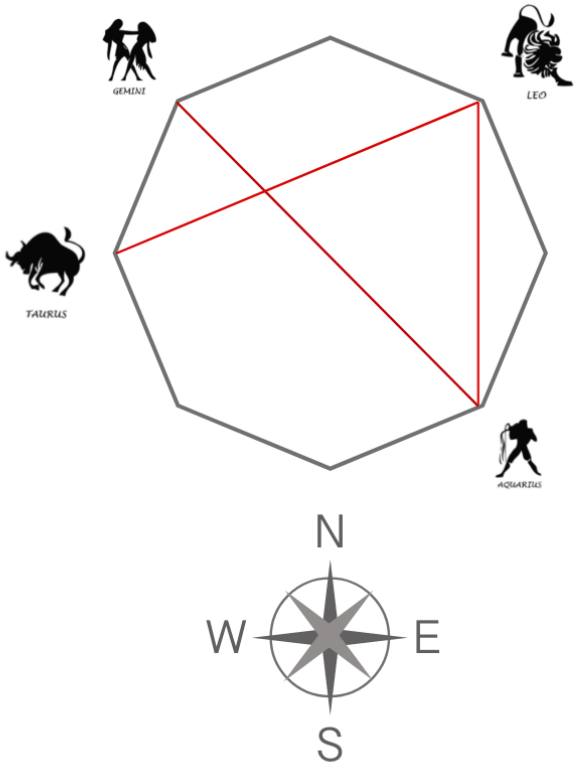


Figure 4.7: Concept sketch of zodiac puzzle.

4.1.1 Tackling Accessibility

Ensuring that a wide range of players can enjoy a generated escape room is a concern that is complex, albeit considerably relevant, to consider. Not only is it important since the number of players with disabilities is increasing as the playerbase is expanding, this also leads to increased legal requirements for accessibility [24]. As mentioned in section 3.1.3, puzzles can generally be categorized as either physically or mentally demanding. Regarding the latter, designing puzzles around the mental capabilities of players represents a topic which could be a project all on its own. Since the focus is on creating a proof of concept escape room generator, it was

decided that the intricate task of taking the mental aspect into account would be excluded and that solely physical constraints would be considered.

It was determined that three major subgroups of impairments could potentially hinder the completion of certain puzzles. These were hearing, visual and mobility-impairment. The first, hearing, relates to puzzles that require sounds or audio to be discerned or listened to for a solution or clue to be extracted. The second, visual, involves inspecting, discovering, or observing visual objects, which often requires sufficiently functioning eyesight and perception. And the third, mobility, covers puzzles where the ability to climb, grasp, reach and move fast or diligently is a requisite. To communicate these limitations, these impairments were added as labels to puzzles that would be generated for the operator of the application. This allows the implementer to either alter how the puzzles are integrated in the room to accommodate for the various impairments or generate new puzzles that are more suitable.

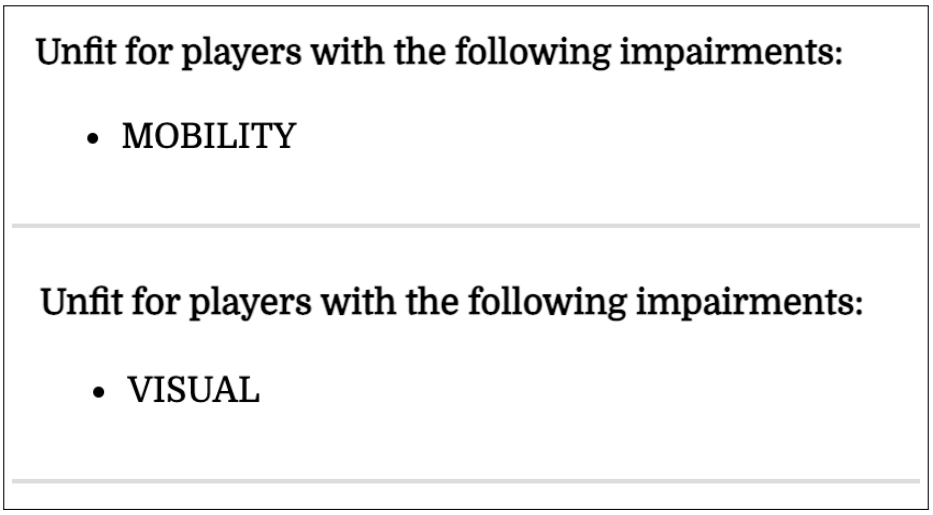


Figure 4.8: Generated labels representing different accessibility categories for puzzle module in the generator.

4.1.2 Graphical Representations for Puzzles

When designing the generator, one key focus is to enable the construction of more complex puzzle modules. These complex modules often have information that is not possible to convey concisely in a text format. An example of this is the Chess puzzle module (Figure 4.9).

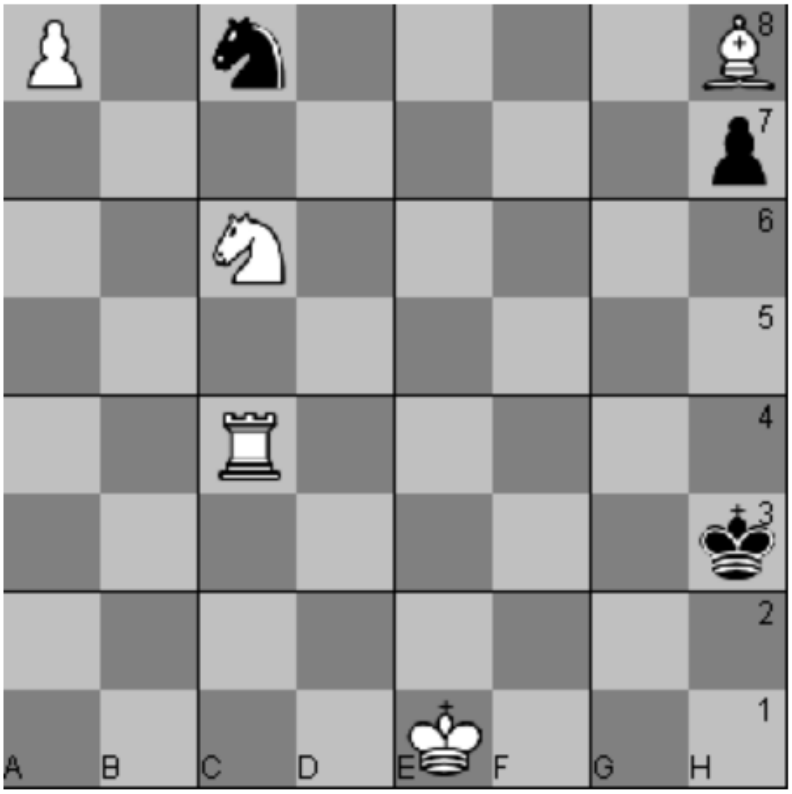


Figure 4.9: Image generated as part of the chess puzzle module.

In this puzzle there are pieces placed on a board in some arbitrary setup. While describing piece placements with chess notation is possible, it may not be practical to the average player of our generator. The player could mistakenly face the board the wrong way or place a piece on the wrong square, making the puzzle unsolvable. A graphical representation may therefore be justified since it minimizes the possibility of misinterpretation by providing a fail-safe that the user can compare their own setup to. With this in mind, the design of custom image generation for these hard to convey parts of puzzles became an integral part of the generator. Puzzle modules using this image generation are the assemble picture puzzle, mirror number, chess, and zodiac.

4.2 Progression Structures in the Generator

There are several different progression structures to choose from when creating an escape room. The progression structure that the generator utilizes is the pyramid progression structure described in section 3.1.2. The most prominent advantage of the pyramid structure over the linear one is that the player may start with *any* of the "leaf puzzles" (see Figure 3.1b). This freedom negates the possibility of getting stuck in a bottleneck at a certain puzzle, thereby halting the general progression of the escape room. The player then has the choice of attempting another puzzle, while they subconsciously try to solve the other halting puzzle. In other words, this ensures that multiple players can collaborate and progress in parallel. This design

choice satisfies the guideline regarding parallelism presented in section 3.1.3.

The lack of progression in a linear structure, given that the player gets stuck at a certain puzzle, is the most fundamental issue with the structure. The upside, however, to this structure of puzzles is the simplicity of it; chaining a set of puzzles in a linear fashion is very easy to generalize. Conversely, the pyramid structure proved to conceptually harder to generalize and generate.

This brings us to the way that the generator structures the puzzles.The number of children for an arbitrary puzzle node, P_n, depends on the number of clues that P_n contains and also the number of puzzles that the escape room should have. A "clue" in this context is a piece of information that is needed (in most cases, exceptions could occur, see section 7.2.3) to solve the puzzle. An example of this could be illustrated with the following generation of a "Mastermind puzzle":

> *"Using the following clues, find the code 356:*
>
> - *796, 1 digit(s) are correct and in the correct position.*
> - *426, 1 digit(s) are correct and in the correct position.*
> - *366, 2 digit(s) are correct and in the correct position.*
> - *936, 1 digit(s) are fully correct, and 1 are correct, but in the wrong position.*
> - *611, 1 digit(s) are correct but in the wrong position.*
> - *800, all digits are incorrect."*

Every bullet point in the generated puzzle above is considered a "clue". This means that to solve the puzzle the player needs six pieces of information. These six clues will be given as rewards from the other puzzles that will be included in the escape room. However, if there are fewer remaining puzzles (to be placed in the structure) than clues to be distributed as rewards, the remaining clues will simply be considered separate clues to be placed in the room for the players to find through exploration. If a clue from a puzzle, P_n, has been set as a reward in another puzzle, P_m, a dependency is established between the puzzles; P_n has become the parent of P_m. This idea of placing puzzle nodes given a list of clues is very useful in terms of generalisation. The process can be recursively repeated until the desired number of puzzles has been added to the structure. The result of this algorithm is a pyramid structure containing generated puzzles as nodes connected by clues represented as edges. Figure 4.10 below shows two example results produced by the generator. For every puzzle node, if it leads to another puzzle an edge is drawn to that puzzle. This means that the top puzzle in the image always represents the final puzzle in the escape room. Furthermore, for every type of puzzle module in the room a randomly generated pastel color is assigned to that module type. This makes it visually easier to see what puzzles in the structure are of the same type.

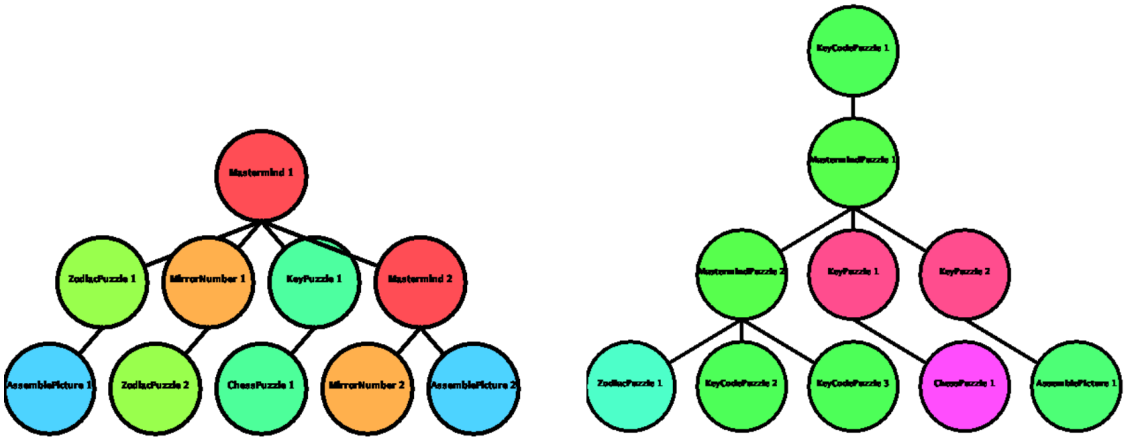


Figure 4.10: Two pyramid structures produced by the generator.

4.3 Generation by Probability

Most escape room creators may have preferences over what types of puzzles that should be more or less frequent in their escape room (see section 3.1.3). They might wish for puzzles that fit their theme of choice or puzzles that are more accessible. These factors needs to be taken into consideration for the generated puzzles to suit the needs of escape room creator.

The way that the generator picks the desired puzzles is analogues to a loaded die; some puzzles are more or less likely to be picked than others. In the case of the implemented generator, the probability for each puzzle is defined in the source code. The following example will describe how the algorithm selects these puzzles:

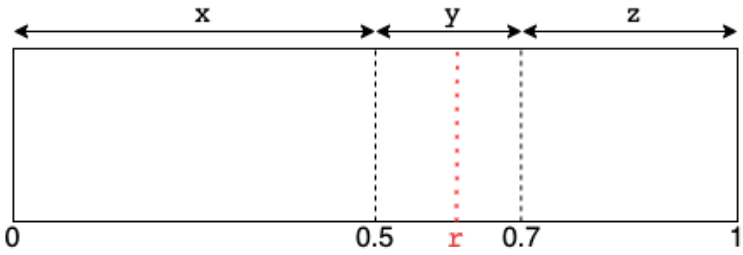


Figure 4.11: Visualisation of the probability subintervals.

Let x, y and z be three different puzzles. Assume that their preferred probabilities of occurring are

$$P(x) = 0.5, P(y) = 0.2, P(z) = 0.3.$$

Note that the sum $P(x) + P(y) + P(z)$ is equal to 1. Let r be a random number between 0 and 1; for the sake of example, let $r \approx 0.61$. With the probabilities of the three puzzles, subintervals are formed within the 0 to 1 interval, depicted in Figure 4.11. This implies that there will be three subintervals for each puzzle.

In Figure 4.11, r is located in the subinterval of y. This means that puzzle y is appended to the list of puzzles to be added to the escape room. This process is iterated until the list contains the number of desired puzzles. With each iteration, a new value for r is randomized.

The reason for choosing this algorithm for picking puzzles was for its simplicity. Picking another more complex algorithm would not have provided more benefit for the generator. Conversely, it might have taken more effort and time spent for the same result.

4.4 Front End

The purpose of this section is to describe the design decisions made when forming the user interface for the generator. While the focus problem of the project mostly involves the back end programming allowing for puzzle generation, adapting the user experience sufficiently is deemed important to ensure the product of the generator is usable by its stakeholders.

4.4.1 Iterations

The first iteration of the user interface focused on just displaying the data generated by the back-end. Since this phase of development required effort to be centered on finalizing the basic infrastructure of the application, functionality was prioritized over aesthetics.

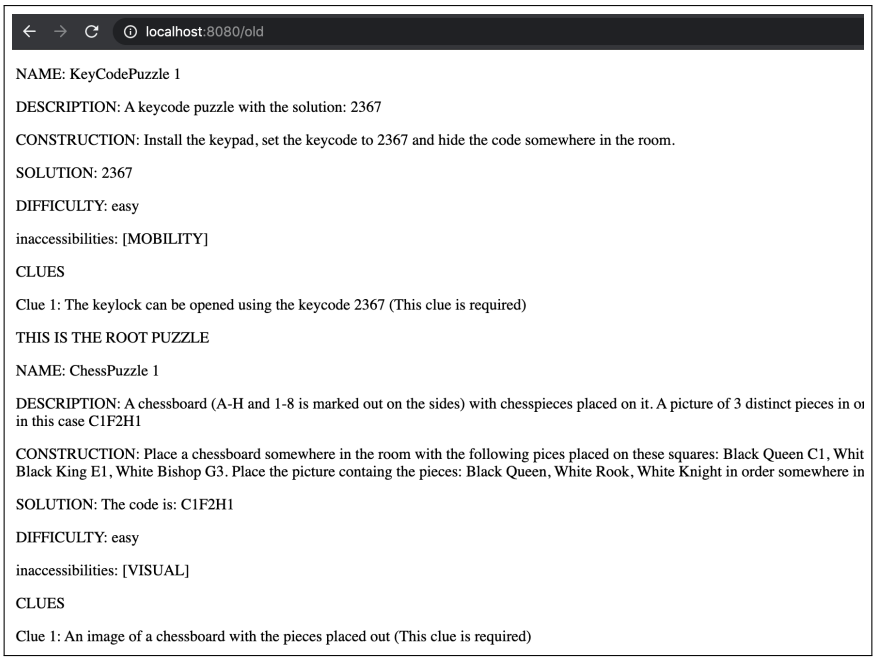


Figure 4.12: First iteration.

The second iteration focused on visually grouping the puzzle modules and their instructions, so that readability could be improved. It also contained one of the

major decisions that shaped the application; What options should the user have access to? Ultimately only one single button was made available to the user at this point, redirecting to the page of generated puzzles after being clicked. While this simplicity might limit customizability, including an interface that allows for several options could infringe on the automation aspect of the application. Therefore, an additional settings page was excluded.

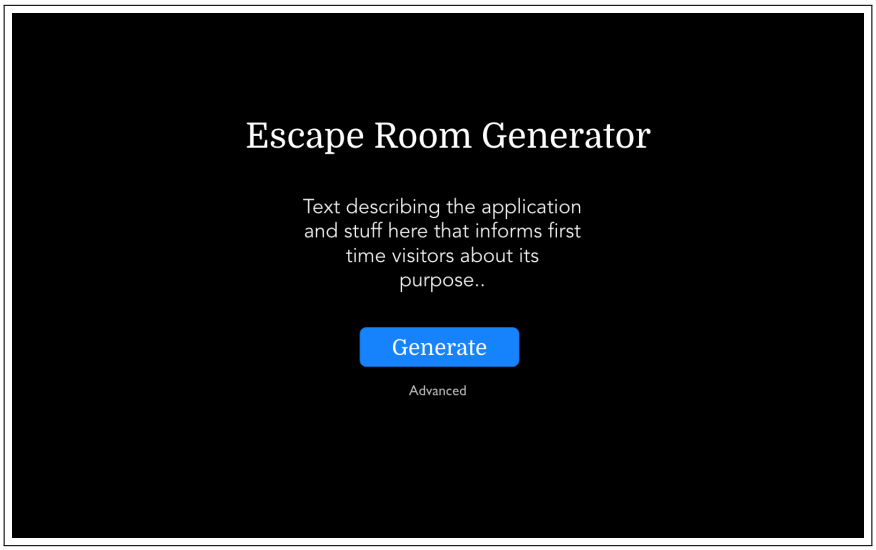


Figure 4.13: Mockup of the homepage.

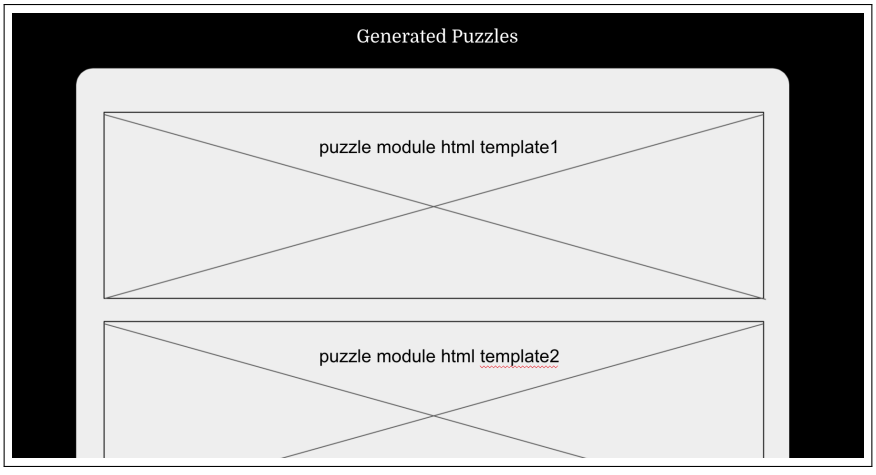


Figure 4.14: Wireframe design of puzzle presentation.

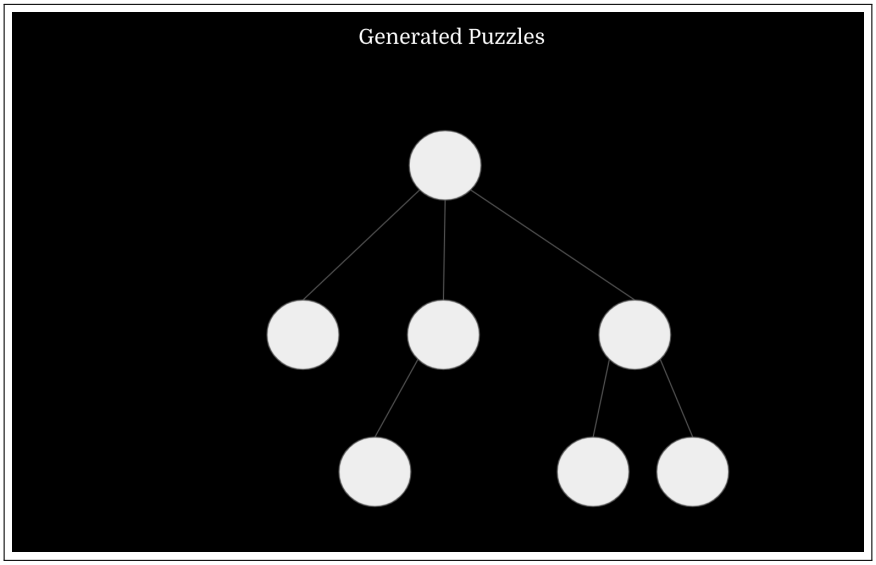


Figure 4.15: Early mockup of the puzzle tree.

During the third and last major iteration, there were still visual improvements missing that could help with the usability of the software. Therefore, another redesign of the interface was carried out, as well as the addition of a button allowing users to generate a single puzzle module. This was done to enable easier testing and allow users to generate individual puzzles of their choice.

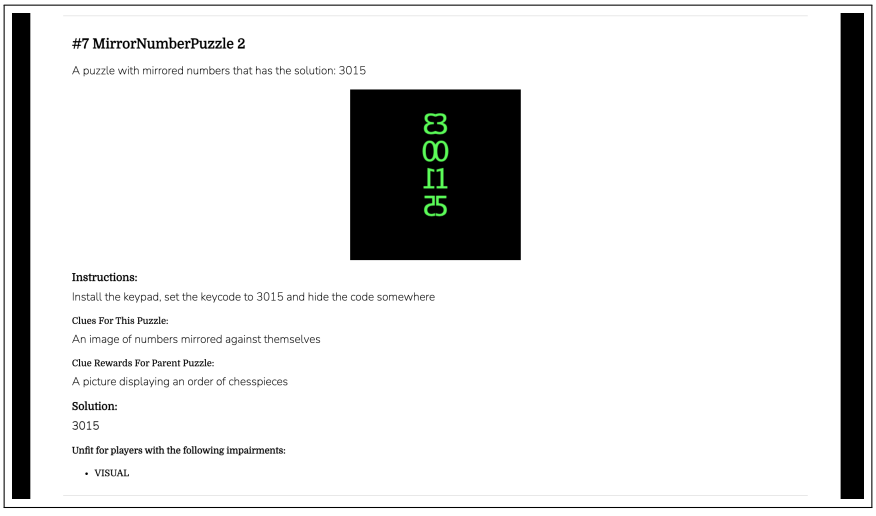


Figure 4.16: Final iteration.

5

Implementation

In this chapter the implementation of the proposed design will be covered. Implementation choices and the development process will also be reflected upon and motivated. This chapter aims to provide a practical understanding of how the design was translated into a working product and how the tools and methods were applied in practice.

5.1 Setup

Before the development of the application began some setup and configuration had to be completed. Firstly, as with any contemporary development project, version control was configured using git and GitHub. Secondly, the web server on which the application would be hosted was configured so that a simple static web page could be displayed when visiting. Given that the generator was to be developed using agile practices a Scrum-board (see Section 2.1.1) was also created as well as a shared document folder for research and other project related documents. For simplicity the application was put in a docker container and deployed. This allowed the server to be completely dependency agnostic. The server was deployed once each sprint, allowing each team member to have a reference for the current stable features.

5.2 Sprints

After the setup of tools had been completed and the research had begun, the first Scrum meeting was held, a product backlog was created and the first entries were added. The following subsections should be seen as a overview of all features and design choices included in each of the sprints.

5.2.1 The First Sprint

In accordance to agile practices, the purpose of this project was to be able to deliver a valuable increment of the product at the end of each sprint. For the first sprint this goal was to be able to visit the web page of the generator, press a button and get a description to be able to construct one simple puzzle. The completion of this goal would ensure that all basic infrastructure is in place, allowing for the application

to be properly sectioned into distinct parts. This enable the project group to more freely develop the application in parallel.

At this point in the development of the generator, parts of the software design for the application itself was yet to be completed. The code base in place by the end of the first sprint was a static paragraph of text describing a very simple puzzle. Conceptualizing the design was the primary task of most team members.

5.2.2 The Second Sprint

The beginning of the second sprint was primarily about establishing a design model for generating puzzles. During the sprints, the group held brainstorming sessions that would lead to the base design of the generator explained in chapter 4. The agreed upon implementation design consisted of the following: an abstract super-class that would model a basic puzzle, a number of distinct puzzle modules that each would be a realization of the super-class, and some generator module that would create rooms from the puzzles modules. The detail of each of these components would continue to be refined and improved throughout the generator's development.

The first real implementation of the desired model for the generator was the abstract super-class for modeling puzzles. Outlining what made a puzzle a puzzle turned out to be no easy task. Some aspects of a puzzle were obvious; all puzzles have a solution, for example. Other aspects, however, were less obvious. These would include aspects like level of accessibility and how to define a clue. The main generator module was also something that caused a lot of debate as to how to best design the relations between puzzles. There were discussions if these connections should be modeled as a tree, a linear structure or some novel design like a DAG. All of these data structures were valid options and could be used to module the structure of an escape room. However, the tree data structure was ultimately the one considered most appropriate given the applicable algorithms as well as the knowledge within the group. A class was added for building such trees in conjunction with a factory class for generating lists of puzzles in a random yet balanced manner. By the end of the sprint, the application was able to generate a tree of puzzles and print them to the front-end. This was then displayed as a long list of paragraphs, describing the information relating to each of the puzzles and how they connect to each other.

For the generator to generate an escape room, different puzzles had to be created and organized. To avoid creating unnecessary dependencies between the generator and specific puzzle implementation and to maintain extensibility, the factory design pattern was used. This was done by creating a class that was given the responsibility of creating puzzles. The factory was designed to provide a list of puzzles according to some predefined distribution model as described in section 4.3. The distribution model used was essentially a stochastic model where the different puzzle modules were weighted according to some desired understanding of what would make the best escape room. Other design patterns were discussed for handling the task of organizing and creating puzzles, such as the decorator design patter. However, the factory design pattern was chosen due to its ability to not only handle the creation of single instances of objects yet also collections of them.

The final feature added to the application in the second sprint was the ability to supply graphical representations for puzzles, as discussed in section 4.1.2. To enable this, an image handler responsible for creating the custom image based on the puzzle type and solution was created. There was however still an issue of how this image could be sent to the front-end since only text can be passed between the server and client. This issue was solved by using Base64 binary to text encoding which can act as a text for an image. This Base64 representation can then be decoded in the front-end producing the image. Different encoding standards were briefly discussed although the main advantage with Base64, that native HTML is able to understand and automatically decode this encoding, made it the method of choice.

5.2.3 The Third Sprint

Until the third sprint, minimal work had been put into the user interface (UI) of the application. Each generated room was represented as a list of plain text paragraphs with associated pictures describing the puzzle in a semi-structured manner. The UI had seen some improvements to readability in the second sprint however, much was still to be desired in terms of useability for stakeholders. In the third sprint a lot of improvement and refinement of the UI was made, as mentioned in section 4.4.1. These design considerations were realized in HTML and CSS code additions, as well as the creation of a script that allowed for URL parameters to be sent to the back-end, which was required for the puzzle duplication setting. Fields were also added in the front-end code to represent the new accessibility status of the different puzzles, informing the user of which puzzles should be reconsidered for players with certain impairments.

The back-end of the application also saw major improvements and refinements. So far, a room was created by means of the factory and the room itself was in essence a list of puzzles. There was no information provided by the generator for how these puzzles were connected and in what order they should be traversed to complete the room. A class for representing a generated room as a tree was implemented to solve this issue. The idea behind this class was that the final puzzle that would grant the escape would be the root node of this tree. The other nodes in the tree would then be the other puzzles in the room and the edges between the nodes would be the clue to a new puzzle given as a reward for completing a puzzle.

6

Result

In this chapter the result of the implementation described in Chapter 5 will be presented as well as the data produced as part of the user testing. This chapter aims to give the reader insight into the final results of the project. These results include functionality of the generator, its graphical interface as well as the data collected as part of user testing for generated escape rooms.

6.1 User Interface

From the implementation described in Chapter 5 a web-application was constructed. This application consisted of three distinct pages, the first one being a homepage (see Figure 6.1). In this page the user is greeted with basic information about the generator and prompted to either press a button to generate an escape room or enter into the second page with advanced options. In addition to this there is also a checkbox that allows or disallows duplicates of the same type of puzzle.

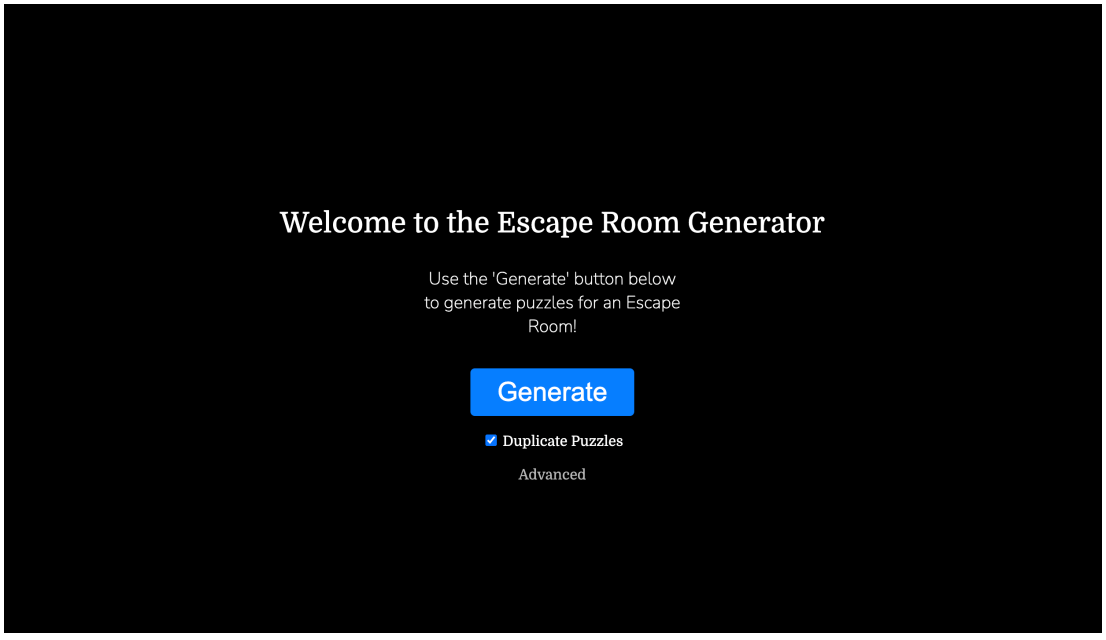


Figure 6.1: The homepage of the generator's web interface.

If the user presses the button for generating an escape room, a new page containing the assembly instructions for the escape room appears. The first part of these instructions is a dynamically generated hierarchical image displaying how the different puzzles in the escape room are linked together. This image, as seen in Figure 4.10, is then followed by assembly instructions for randomly generated variations of different puzzle modules. These instructions (see Figure 6.2) consist of how to build the module, what clue it should give, connecting it to another module in the room, and information about the puzzle's accessibility. In addition to these instructions, the page similarly to the homepage also contains a generate button if the user wish to generate a new room.

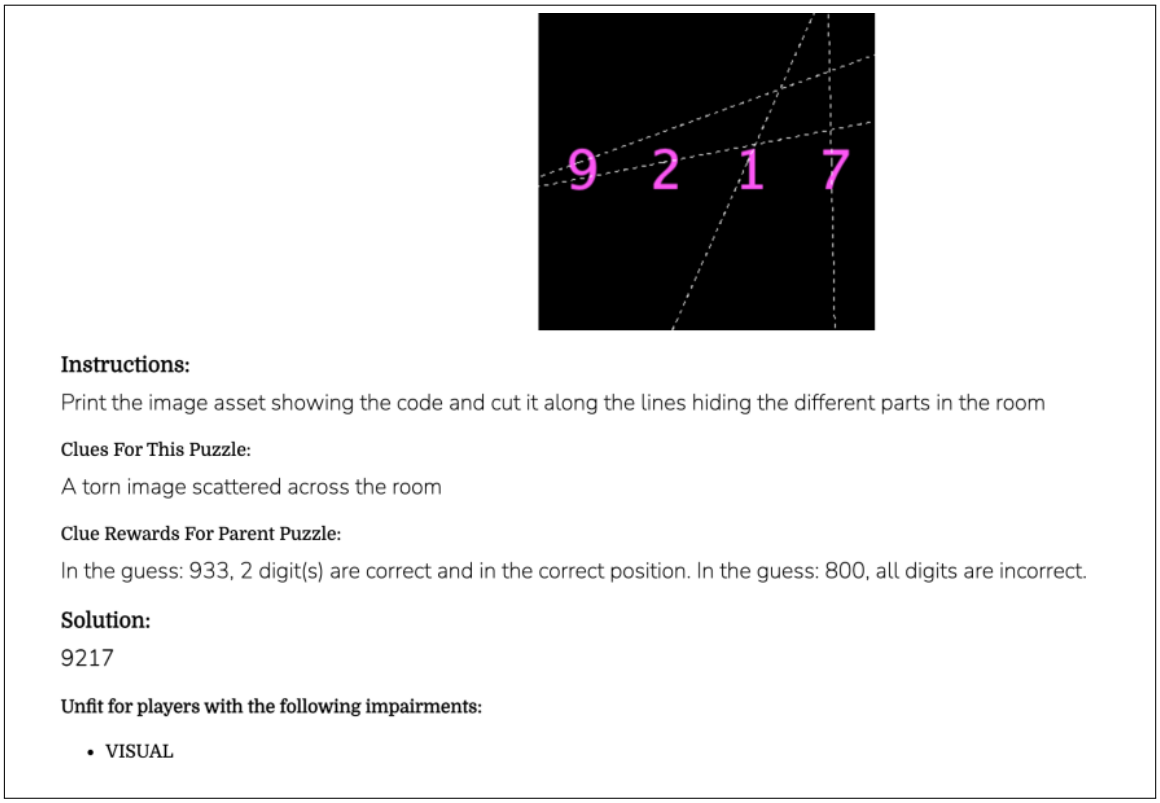


Figure 6.2: An example of a generated instruction for one puzzle module.

The third and last page is the advanced menu reached by pressing the advanced button in the user interface. This menu allows the user to generate individual modules of any puzzles currently in the generator.

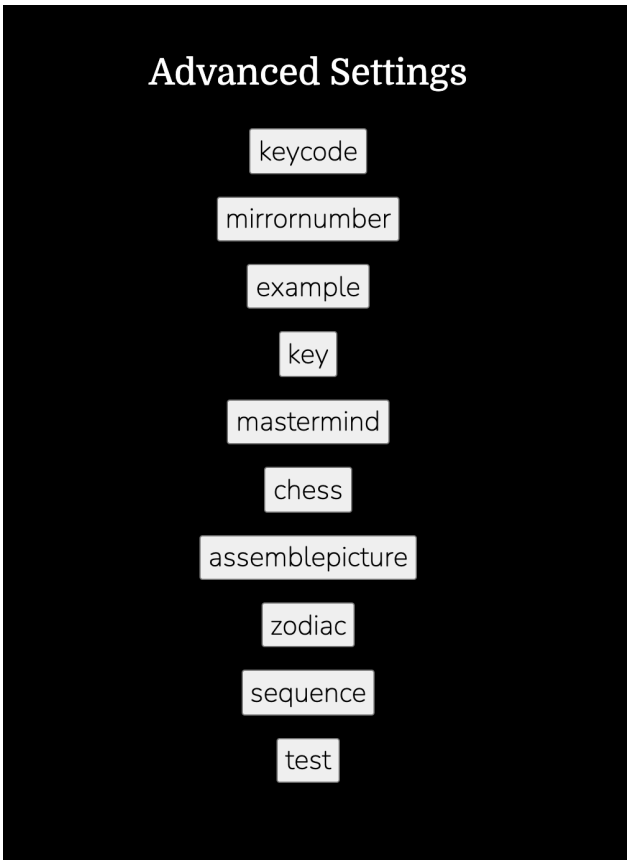


Figure 6.3: Advanced page, including modules used during development

6.2 User Testing

As discussed in section 2.5, the method of user testing was performed in two escape rooms. The participants were divided into six groups, for a total of twelve participants. A majority of these groups were students at Chalmers between 18 and 29 years old.

For each group a game master explained the following rules:

- The group has 30 minutes to finish the room, to finish the room the group have to solve the last puzzle.
- The game master will give information about the time when 15, 10, and 5 minutes remain on the clock.
- If the group at any point gets stuck they can ask the game master for an unlimited amount of hints.
- It is important to explore the room for clues and puzzles.

The test groups attempting the linearly structured room all managed to complete it within 30 minutes, whereas the groups attempting the pyramid rooms required additional time. After the participants had finished the escape room, interviews were conducted. The answered questionnaires from the participants can be found in

appendix A, all of which were anonymous. In appendix B a compiled set of graphs for the answers can be found. Figure 6.4a and Figure 6.4b depict the flowcharts of the linear and pyramid escape room, respectively.

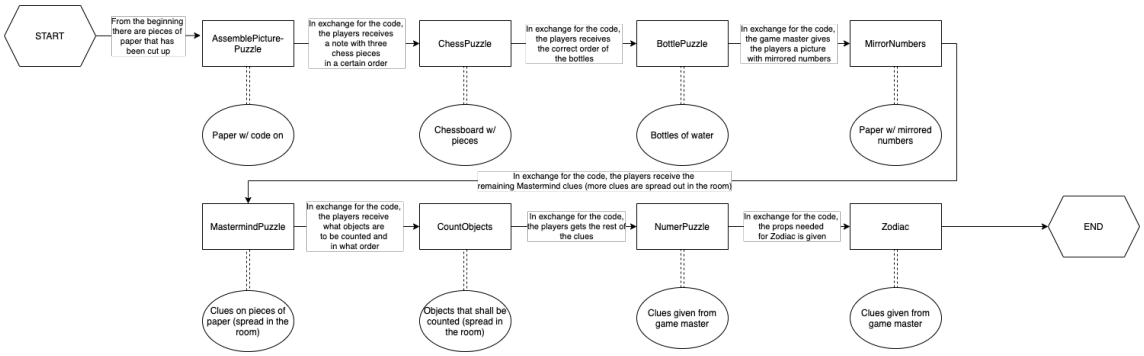


Figure 6.4a: Flowchart of the linear escape room used for user testing.

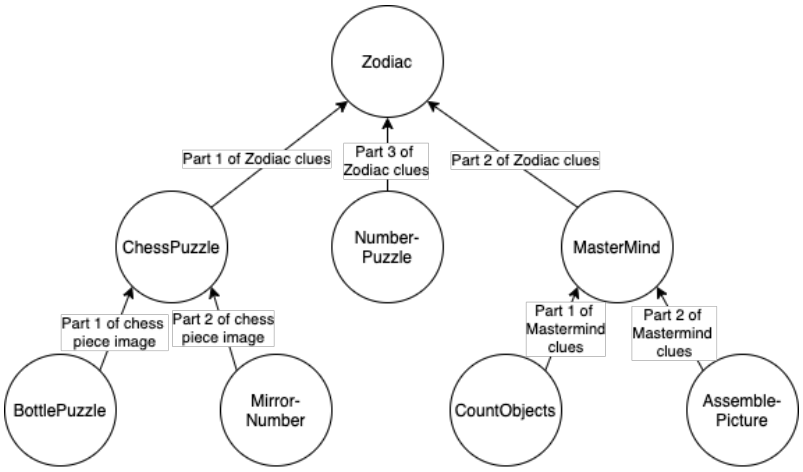
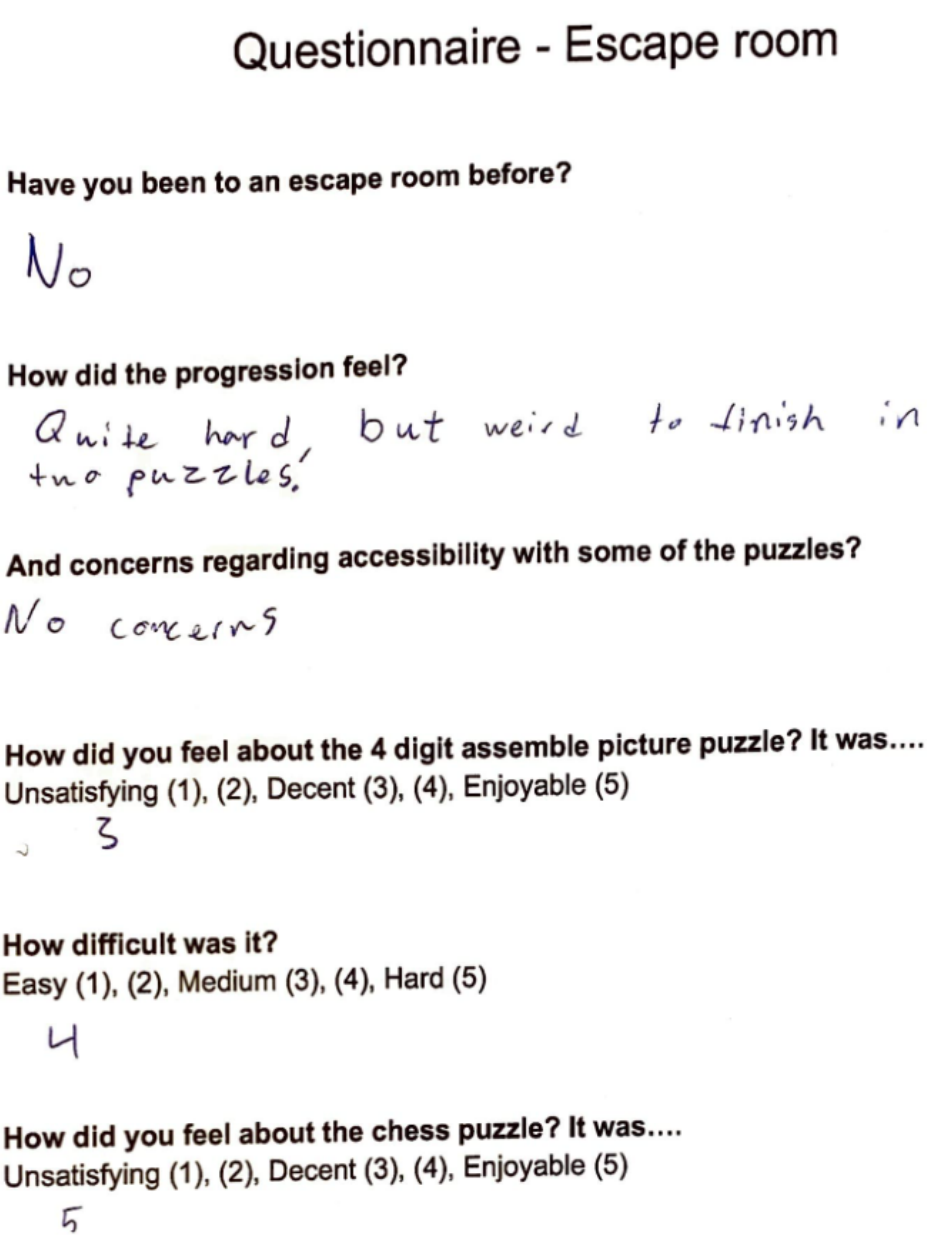


Figure 6.4b: Flowchart of the pyramid escape room used for user testing.

The testing exclusively targeted player enjoyability of the generated rooms, not usability of the application itself. As such, the testing done did not target construction of the rooms. However, testing enjoyability is still valuable since it is highly subjective and therefore difficult to achieve only using a theoretical model. Also, unforeseen problems with the generated room, which might impact the experience, can through user testing be observed and fixed.

6.2.1 Interview Results

On average, participant interviews resulted in the linear escape room being regarded as slightly more enjoyable than the pyramid alternative. Specifically, the mean value of enjoyability for the linear room was 3.98, slightly higher then the pyramid room's 3.67, both being rated between decent and enjoyable. However, the mean difficulty result was identical for both rooms, 2.71, almost medium difficulty.



Questionnaire - Escape room

Have you been to an escape room before?

No

How did the progression feel?

Quite hard, but weird to finish in two puzzles.

And concerns regarding accessibility with some of the puzzles?

No concerns

How did you feel about the 4 digit assemble picture puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the chess puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

Figure 6.5: Example survey.

When explicitly observing the data relating to previous escape room experiences, the results differ moderately. On average, participants with no previous experience gave enjoyability a rating of 4.1, fairly enjoyable, while those with previous experience gave it 3.57, moderately exceeding decent. Difficulty featured a similar disposition, 2.63 from those with previous experience and 2.76 from those without, both rating it somewhat easier than medium difficulty.

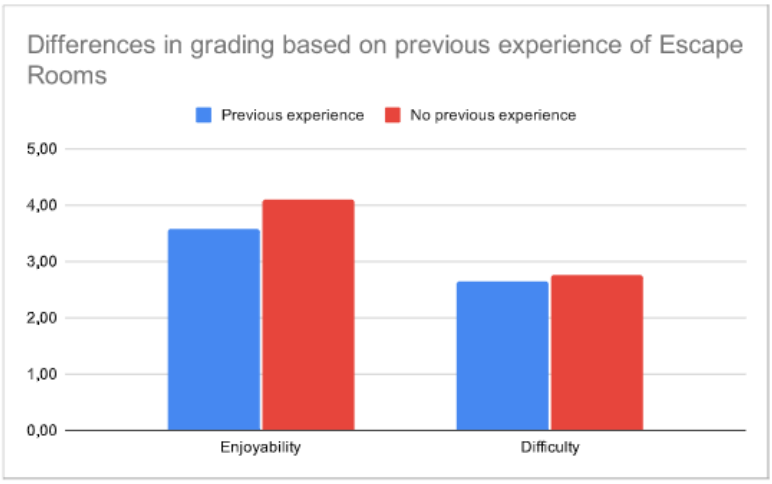


Figure 6.6: Graph comparing enjoyability and difficulty.

The data also revealed that there is no obvious correlation between enjoyment and difficulty, see figures below.

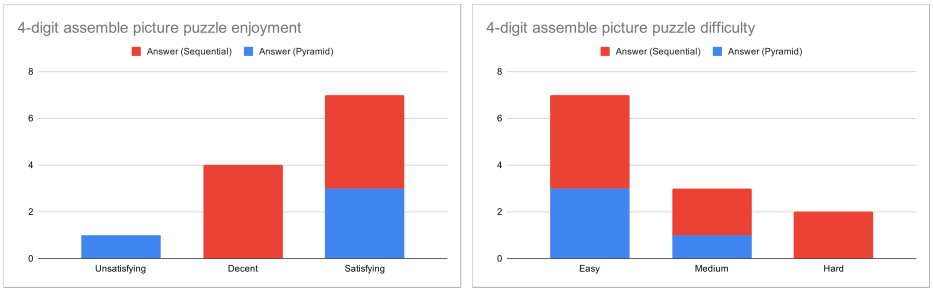


Figure 6.7a: Graph of 4-digit assemble picture puzzle enjoyability and difficulty.

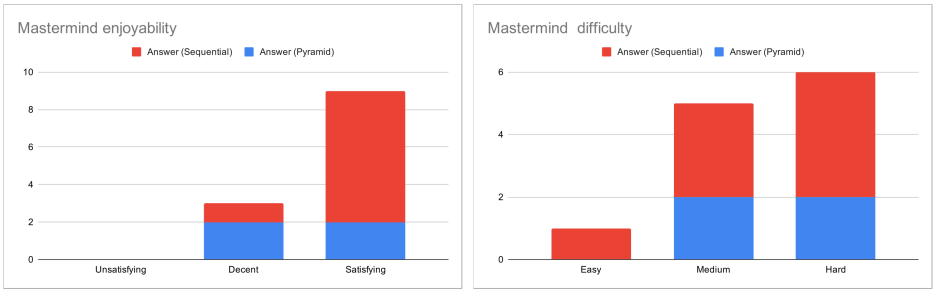


Figure 6.7b: Graph of mastermind enjoyability and difficulty.

By comparing Figure 6.7a and Figure 6.7b, the data suggest that puzzles that are generally considered satisfying, are as likely to be considered easy (4-digit assemble picture puzzle) as hard (Mastermind).

7

Evaluation & Discussion

To ensure quality of our end product, evaluation needs to be conducted. These evaluations are based on the results presented in chapter 6. The results will also be discussed with regards to the purpose presented in section 1.2.

7.1 Technical Evaluation

Though many tasks have been completed during this project, the goal has always been the construction of an escape room generator. Such a generator should provide instructions for how to install an escape room with all its puzzles. The final product is functioning and fulfills the purpose of the project. The generator provides a structured set of instructions for each of the puzzles generated for a particular room. Additionally, it provides information on how these puzzles interconnect and form an actual escape room. The generator even provides a graphical representation of how the generated puzzles are organized, which exceeds the list of planned features established prior to the development of the generator. Regarding providing a proof of concept, the project is a success and could, due to its modular design, be expanded in the future.

Some improvements could be made to the quality and quantity of the puzzle modules. The final product contains seven functioning puzzle modules. This is enough to create a proof of concept for the generator although, though arguably not enough for the generator to have any significant impact on the industry. However, given the extensible design of the generator, additional puzzle modules could be added to such an extent and with such diversity that it could be of use in the industry. Moreover, the most valuable improvement that could be made to the generator would be in regards to enabling non-programmers to add their own content. In the current state of the generator, if the user wishes to add additional puzzle modules the user must first have access to the source code, and secondly basic knowledge of class design in Java. This makes it very unlikely that extensions to the pool of puzzle modules would be made by anyone without this knowledge. To solve this issue, the best solution would most likely be to make it so that a user could add additional puzzles modules as part of the application. This could open the possibility for different users to create their own set of puzzles and then share these puzzles with each other. This feature, along with having a dedicated online platform for sharing the puzzles, is arguably what is missing for the generator to have a meaningful impact on how escape rooms are constructed today.

Another important aspect to evaluate is if the purpose of providing users with coherent instructions has been fulfilled in the final version of the generator. The generator provides a organized set of instructions, which alone would make the project successful regarding this specific purpose. In addition to providing plain text output describing the puzzles, the generator also provides graphical representations for certain puzzles and a sufficiently designed user interface for ease of interaction.

The front-end of the generator has exceeded the expectations of the group however there is still room for improvement. For example, interactive elements could be added to improve the navigation between puzzles. Currently, if a user wishes to gain an in-depth understanding of how a particular puzzle leads to the final puzzle of the room, extensive scrolling would be required to see how it all fits together. Arguably, the user experience could be significantly improved if the user were able to select particular paths of interconnected puzzles from beginning to end. The ability to gain an in-depth understanding of a specific puzzle and its context could also be improved by allowing the user to enter a detailed view of a specific puzzle, as opposed to a list view of all puzzles. In the detailed view, more information could be provided that would be considered superfluous in the list view.

7.2 User Testing

This section aims to provide reflections and evaluations on the results from the performed user testing, see section 6.2.

7.2.1 Attempting Unsolvable Puzzles

In both the pyramid and linear escape rooms, there were clues hidden throughout the room which were required to solve some of the puzzles. These hidden clues were usually a part of a larger context and are not on their own enough to solve a puzzle. In the pyramid escape room, subjects were also rewarded with sub-clues, clues divided into multiple parts. These hidden clues, and the sub-clues in the pyramid escape room case, had subjects attempt to solve puzzles that were unsolvable with only the clues they currently had. Although this issue was more prominent in the pyramid escape room, it was still an issue in both rooms. A feasible solution to this problem might be to have a clue-status indicator, conveying the existence of remaining clues to players and informing them of what clues to which puzzles have been obtained.

7.2.2 Exploring the Room for Clues

When the subjects entered the escape rooms and the timer started, most went to the puzzles presented in plain sight. However, throughout the entirety of the game, most groups did not realize that there were also clues hidden in the room. Since some puzzles were unsolvable without these clues the game master had to give a few groups hints concerning this. It is uncertain whether this should have been explained beforehand or not since it could have impacted the experience negatively

by giving the subjects to much information. Interesting to note nonetheless was that there was no obvious difference between the subjects that had played escape rooms before and the subjects that had not, when it came to exploring the room. Although interesting, it is not within the scope of the project.

7.2.3 Brute Forcing and Unintentional Shortcuts

During one of the user testing sessions, one group managed to skip several of the puzzles that were meant to be mandatory to progress in the linear room. It was done by recognizing the pattern in the Number Word Play puzzle without obtaining the clue that was considered a requirement for the solution. This strategy was especially impactful since the linear structure of the room rewarded this avoidance, unlike a pyramid room where at least one other puzzle could have been blocking such unforeseen rapid progression. However, it was difficult to determine whether the said event negatively or positively affected the experience. On one hand, it could be argued that missing several potentially stimulating puzzles is a net-loss. On the other hand, the act of strategically skipping parts of the room to receive a better completion time could be regarded as a puzzle that in itself is enjoyable. While it might count as an instance of exploiting weaknesses in the design, it should not be compared to the act of brute forcing puzzles. Brute forcing implies repetitive attempts using the same method until it works, without requiring a change of perspective, strategy or thinking. Since it does not incentivize creative thinking, it should if possible, be prevented. A simple fix would be to generate a new solution after each attempt, making the puzzle almost impossible to solve without adopting a more intelligent strategy. Furthermore, this approach is supported by the escape room generator itself since it randomizes the solution each time a puzzle is instantiated. This solution does require that parts of the puzzles are designed with randomization in mind. However, if brute-forcing takes place because players determine that the effort required to discover the optimal strategy is not worthwhile, then dealing with that essential problem might require a smarter design solution. A first step could be to rethink how players can take advantage of hints to progress.

7.2.4 Hints and Time Management

During user testing, the game masters noticed a reluctance among the participants when it came to requesting hints. This despite being told explicitly before starting the room that the game masters are there to give hints for when the groups got stuck. Some of the groups attempted to use trial and error techniques before asking for hints from the game master. The game masters noticed that groups who did not ask for hints became more frustrated than those who did.

The game masters have a few theories for why groups did or did not ask for hints. Firstly, the groups were more likely to ask for hints directly after a time reminder, indicating that participants are more likely to ask for help when pressed for time. Secondly, the groups which asked for help once were more likely to ask for help again which suggests an increasing willingness for receiving hints based on how many times the participants have done it before. Lastly, one could argue that asking for hints

disrupts the participants' flow. This is since the game master is a not part of the puzzle, therefore asking them for hints could hurt the immersion of the players.

7.2.5 Presentation of Solutions

As discussed in section 2.5, the puzzles used two different models for presenting the solutions for puzzles. The linear room used a computer with a code-entering program, and the pyramid room used the puzzle master as a wizard of oz. In a regular physical escape room there are usually different kinds of locks. These locks usually make it clear what kind of key they accept. For example, a code lock will usually accept a key of four digits. The methods used in the user testing lacked this clarity. In the code entering program the participants could enter an alpha-numeric sequence of any length, which is a far broader answer space than four numeric digits. In the wizard of oz case the answer space is again very large, this time being anything that could be said to the game master. This led to the realization that the method of solution entry could itself be considered a clue for how to solve the puzzle. When one enters a room and sees a large red lock, one instinctively starts looking for a red key, similarly if one sees a three digit combination lock, one is going to look for three-digit combinations.

7.3 Conclusion

To determine whether the project fulfilled its purpose, it first must be dissected into separate parts. There were three main aspects: whether the generator itself and the use of it worked as intended and if the generated escape rooms were deemed enjoyable by the individuals participating in the user testing.

As discussed in section 7.1, the goals that were set for the generator's functionality was achieved, while also exceeding said goals. Furthermore, there still exists potential for the generator to become a practical tool for escape room creators. The current state of the generator can be considered a proof of concept.

When it comes to determining whether the generator worked as intended is difficult. Since it could create puzzles with instructions that were interconnected, it would on that basis achieve what it set out to do. However, since a user should be able to, on their own, use the generator to set up a functioning escape room, the question cannot be answered since user tests was never performed to validate whether random individuals could, through the usage of the generator, successfully do so.

Lastly, as discussed in section 6.2 according to the individuals participating in the user testing, the escape rooms were enjoyable. However, the test sample was small and all individuals that participated had some sort of relationship with at least one of the individuals in the project group. Therefore, it is not unlikely that they through biases gave a higher rating on enjoyment than what was genuinely experienced. Furthermore, although not a part of the purpose it was interesting to see that there was no convincing correlation between a puzzle's difficulty and level of enjoyment, as discussed in section 6.2.1.

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A

User Test Questionnaires

This appendix contains the questionnaire answers from participants in our user tests. Note that some of the answers are in Swedish.

Pyramid

Questionnaire - Escape room

Have you been to an escape room before?

Yes

How did the progression feel?

Random, but working towards a goal. Satisfying.

And concerns regarding accessibility with some of the puzzles?

–

How did you feel about the 4 digit assemble picture puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the chess puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the mastermind puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

Pyramid

Questionnaire - Escape room

Have you been to an escape room before?

Yes

How did the progression feel?

Slightly confusing, particulary knowing which test to go to next

And concerns regarding accessibility with some of the puzzles?

Man måste kunna lösa.

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

2

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

2 mainly tedious

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

2

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

Mainly because we didn't get it

How difficult was it?
Easy (1), (2), Medium (3), (4) Hard (5)

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4) Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3) (4), Hard (5)

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2) Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

Pyramid

Questionnaire - Escape room

Have you been to an escape room before?

Nej

How did the progression feel?

Bra men otydlig, det var svårt att förstå var man skulle. Det är dock positivt.

And concerns regarding accessibility with some of the puzzles?

How did you feel about the 4 digit assemble picture puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the chess puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the mastermind puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

Pyro

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

2

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

5

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

Pyramid

Questionnaire - Escape room

Have you been to an escape room before?

NO

How did the progression feel?

It felt good, some parts were difficult but it felt like we progressed in the room.

And concerns regarding accessibility with some of the puzzles?

I thought that all puzzles were acessable

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

1

Linear 6

Questionnaire - Escape room

Have you been to an escape room before?

No.

How did the progression feel?

Interesting and cryptic.

And concerns regarding accessibility with some of the puzzles?

The table compartments did not feel like they could be opened.

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

Linear

Questionnaire - Escape room

Have you been to an escape room before?

Yes

How did the progression feel?

~~Sometimes a bit slow if we got~~

good. sometimes a bit slow when we didn't know if we could type in letters as well on the code. Was also hard to know when to type out numbers or write "2"

And concerns regarding accessibility with some of the puzzles?

Blind people, can't reach down the table if you're in a wheelchair. If you don't have a knowledge of RAM its hard to know how many we have.

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

(5)

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

(2)

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

(3)

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

(4) hard to know which order to type letters and numbers

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

(4)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

(4) missed a clue

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

(3)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

(1)

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

(4)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

(5)

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

(3)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

(4) did not know how to ehter the code should write "1" "2" "3" on them with a pen etc.

Lineas

Questionnaire - Escape room

Have you been to an escape room before?

yes, 1 time

How did the progression feel?

Good, it was fun

And concerns regarding accessibility with some of the puzzles?

good, it was no problemes

How did you feel about the 4 digit assemble picture puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the chess puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the mastermind puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

you can just try 10 combinations without clues.

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

I liked the coffee, sit text puzzel

also the 5 = one five = 15 ....

Lineas

Questionnaire - Escape room

Have you been to an escape room before?

Ja

How did the progression feel?

hajs, inte för svårt

And concerns regarding accessibility with some of the puzzles?

Svårt utan händer. Om man inte vet vad vissa saker är kan de bli svårt t.ex. ett Ram mime eller stjärntecken

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

Linear5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

min favorit vaden med

5 = one five

Linear

Questionnaire - Escape room

Have you been to an escape room before?

No

How did the progression feel?

Quite hard, but weird to finish in two puzzles.

And concerns regarding accessibility with some of the puzzles?

No concerns

How did you feel about the 4 digit assemble picture puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the chess puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the mastermind puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

2

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

5

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

Comments:
Zodiac:
- Ingen anings → Förstår ej
- Svårt att testa sig fram

Linear

Questionnaire - Escape room

Have you been to an escape room before?

Nej

How did the progression feel?

linjärt med peaks av "big brain" eureka moments.
kompass var lite bökigt på mobilen

And concerns regarding accessibility with some of the puzzles?

Nä

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

3

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)
4

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)
2

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)
1

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)
5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)
5

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)
3

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)
2

Comments
- Förvånade oss att inte behöva leta efter delar!

Linear

Questionnaire - Escape room

Have you been to an escape room before?

No

How did the progression feel?

Första va lite svårt att förstå att den va först. Men annars kändes det bra!

And concerns regarding accessibility with some of the puzzles?

Man måste ju kunna engelska, men annars tänkte vi inte på något.

How did you feel about the 4 digit assemble picture puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the chess puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?

Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the mastermind puzzle? It was....

Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

Linear

Questionnaire - Escape room

Have you been to an escape room before?

No

How did the progression feel?

Svårt att veta var man skulle börja, sedan flöt det på

And concerns regarding accessibility with some of the puzzles?

Måste kunna eng.

How did you feel about the 4 digit assemble picture puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the chess puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

2

How did you feel about the mastermind puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

3

How did you feel about the Mirrornumber puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

4

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

1

How did you feel about the zodiac puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

4

How did you feel about the bottle puzzle? It was....
Unsatisfying (1), (2), Decent (3), (4), Enjoyable (5)

5

How difficult was it?
Easy (1), (2), Medium (3), (4), Hard (5)

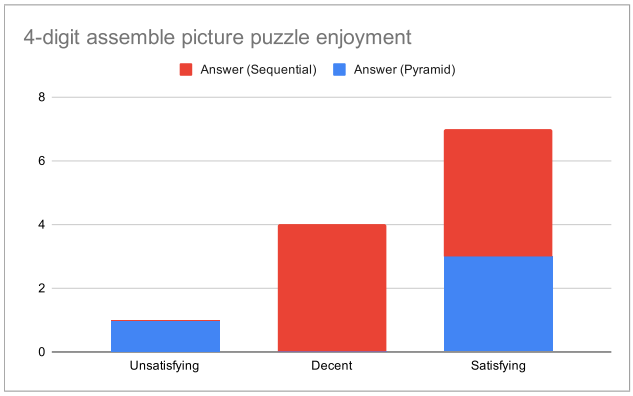
1

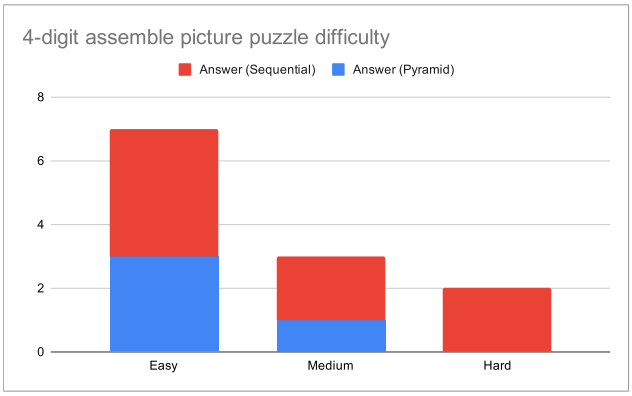
B

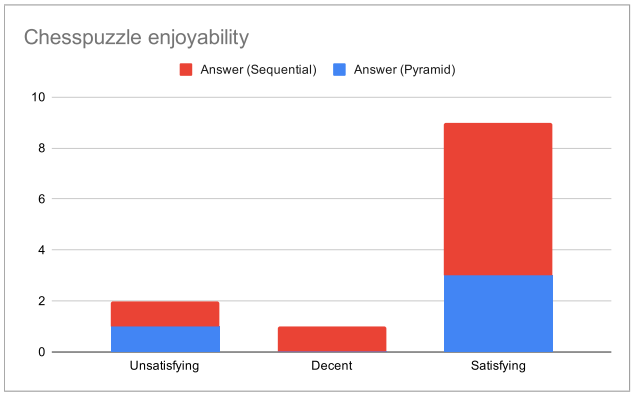
User Test Graphs

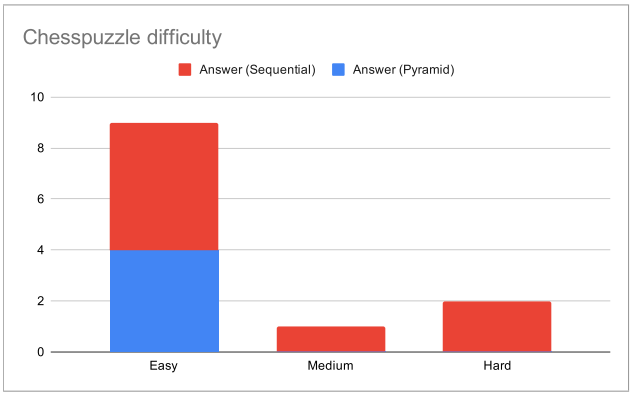
This appendix contains visualization of collected data seen in Appendix A. The graphs for questions 4-15 are collapsed so a score of 1 or 2 is seen as disagreeing with the statement, a 3 is seen as being neutral and 4 or 5 is seen as agreeing.

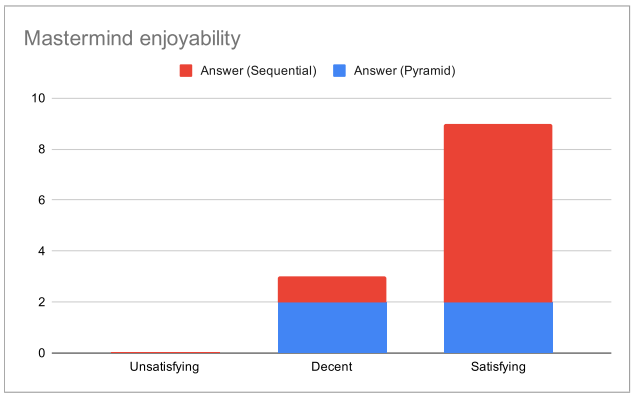
Based on what room structure the participant played and if they had played an escape room before the mean scores for perceived enjoyment/difficulty were also compared in the bottom three graphs.

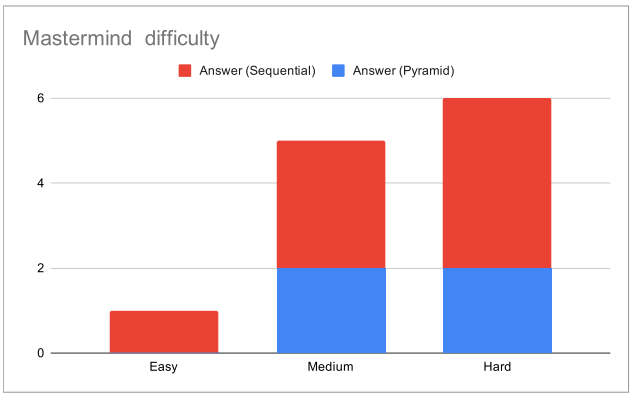

4-digit assemble picture puzzle enjoyment
Answer (Sequential)
Answer (Pyramid)
8
6
4
2
0
Unsatisfying
Decent
Satisfying

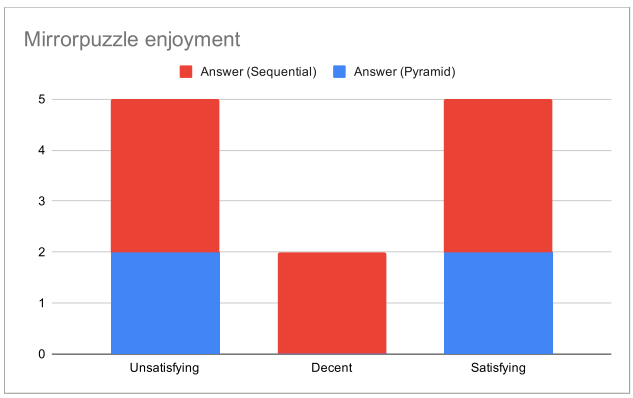

4-digit assemble picture puzzle difficulty
Answer (Sequential)
Answer (Pyramid)
8
6
4
2
0
Easy
Medium
Hard

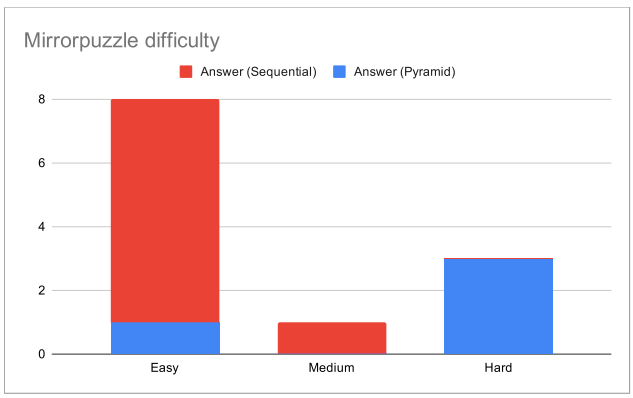

Chesspuzzle enjoyability
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Unsatisfying
Decent
Satisfying

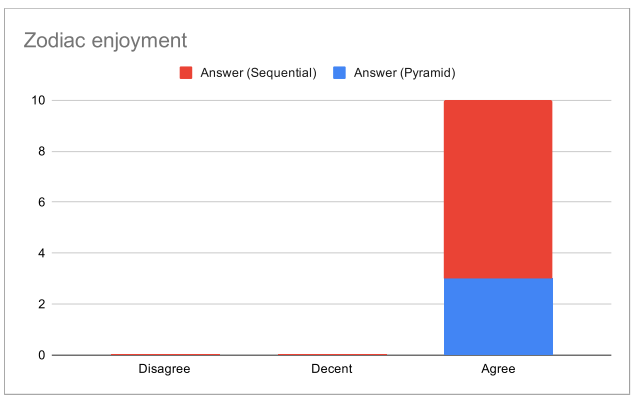

Chesspuzzle difficulty
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Easy
Medium
Hard

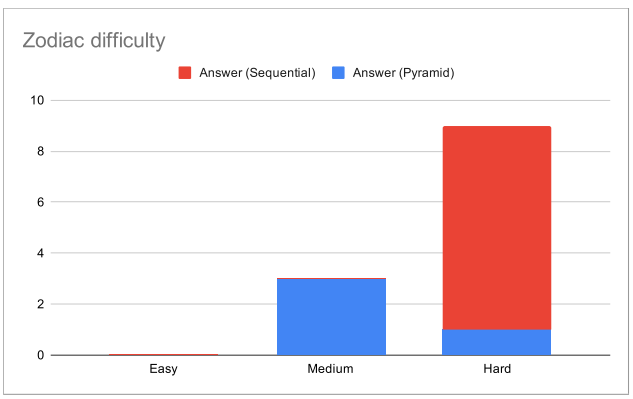

Mastermind enjoyability
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Unsatisfying
Decent
Satisfying

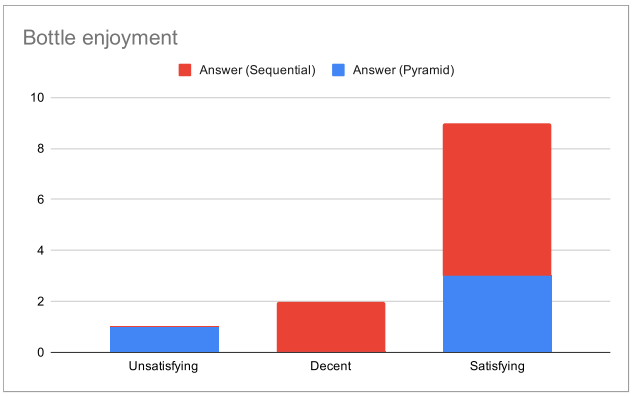

Mastermind difficulty
Answer (Sequential)
Answer (Pyramid)
6
4
2
0
Easy
Medium
Hard

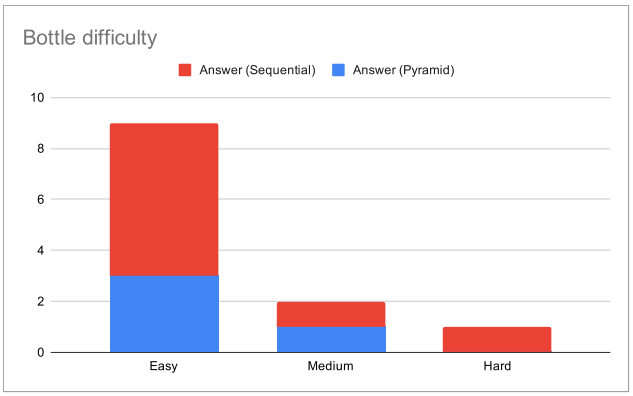

Mirrorpuzzle enjoyment
Answer (Sequential)
Answer (Pyramid)
5
4
3
2
1
0
Unsatisfying
Decent
Satisfying

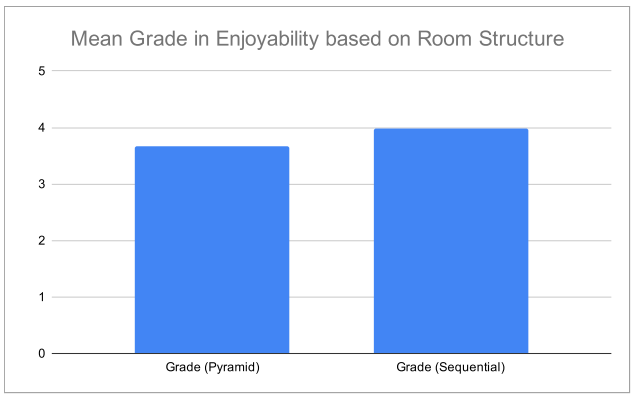

Mirrorpuzzle difficulty
Answer (Sequential)
Answer (Pyramid)
8
6
4
2
0
Easy
Medium
Hard

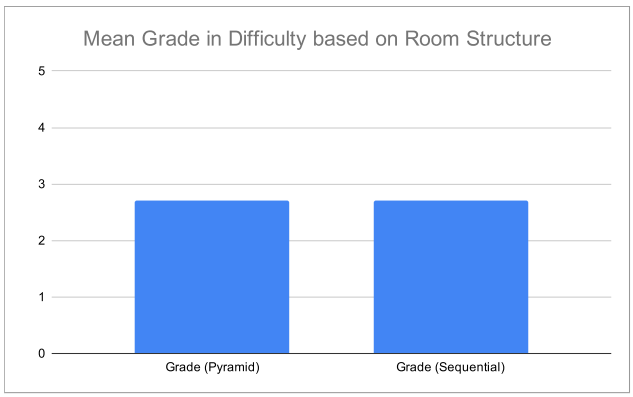

Zodiac enjoyment
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Disagree
Decent
Agree

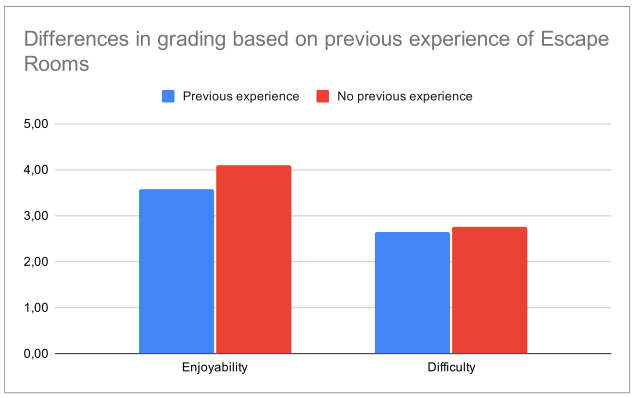

Zodiac difficulty
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Easy
Medium
Hard


Bottle enjoyment
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Unsatisfying
Decent
Satisfying


Bottle difficulty
Answer (Sequential)
Answer (Pyramid)
10
8
6
4
2
0
Easy
Medium
Hard


Mean Grade in Enjoyability based on Room Structure
5
4
3
2
1
0
Grade (Pyramid)
Grade (Sequential)


Mean Grade in Difficulty based on Room Structure
5
4
3
2
1
0
Grade (Pyramid)
Grade (Sequential)


Differences in grading based on previous experience of Escape Rooms
Previous experience
No previous experience
5,00
4,00
3,00
2,00
1,00
0,00
Enjoyability
Difficulty