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Educational escape rooms to raise awareness of the climate crisis

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Abstract

This paper presents an educational escape room puzzle prototype about the climate crisis with the goal of raising awareness about the climate crisis and motivation to participate in the educational workshop. Since educational escape rooms are particularly popular with younger generations, the goal was to bring green energy closer to this generation. This can lead to climate-friendly alternatives being considered, for example when building a house or buying a car.

The puzzle prototype consists of four separate microcomputer systems integrated in a base plate and a fuse box. Together they form a puzzle chain made up of three part puzzles and a base plate controller. The project is part of an educational escape room in an Airstream caravan. In order to test and evaluate the prototype, playtests were carried out to test the integration of the requirements and usability using a survey.

The results show successful integration of the requirements and positive feedback from playtest participants and the project team. 91% of participants reported being highly motivated to take part in the workshop after playing the puzzle. In addition, important game requirements such as playtime and level of difficulty were applied and checked. With a high degree of interaction and magical moments, the prototype offeres participants an experience that not only draws attention to the topic of the climate crisis but is also fun to play in a group. After the playtest the participants also expressed necessary and possible improvements for future work on the prototype.

This paper provides a foundation for further development and testing of microcomputer controlled puzzles in educational escape rooms and the impact on the level of excitement and on motivation.

Acknowledgment

This bachelor thesis would not have been possible without the support and encouragement of many individuals. I would like to express my sincere gratitude to all of them.

First of all, I would like to express my deepest appreciation to my supervisor Dr. Angelika Mader and my critical observer Dr. Robby van Delden, for your valuable guidance, help and encouragement throughout the project.

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Many thanks to Team Escape Münster for allowing me to look behind the scenes of a commercial escape room and interview guests.

Finally, I would like to thank my family and friends for their unwavering support and encouragement throughout this journey.

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Chapter 1 - Introduction

The climate crisis is one of, if not the, biggest challenge that humanity will ever have to face. Only two degrees can make a difference between habitability and uninhabitability on Earth. These two degrees decide whether humanity can continue to live happily or whether it will have indescribable negative effects on the future of the earth and its inhabitants. Global warming should be the number one priority these days when looking into the future, as negative effects could be noticeable in less than 25 years if greenhouse gas emissions do not change [50]. Especially for younger generations, this change will play a major role in their future. Many take this warning seriously but too few take action and change their way of life. This is due to the peculiarities of human thinking, according to behavioral psychologist Sütterlin [48]. Traveling on vacation by plane seems more attractive than the positive effects of not traveling by plane that will appear at some point in the future.

The team around Stefan Heinrich, consisting of more than 30 volunteers, has made it their mission to communicate the topic of the climate crisis in a playful way and to motivate people to learn about climate-friendly actions. My client Stephan Heinrich works in the field of climate communication and describes the climate crisis primarily as a communication crisis. In his opinion, it is not enough to talk about climate facts, but rather to use emotions to motivate climate friendly actions. To achieve this, he purchased an old Airstream RV from 1958 (figure 1) and converted it into an educational escape room on wheels with the topic of the climate crisis. The ultimate goal for the mobile escape room is to drive from city to city and event to event to reach and motivate as many people as possible. He and his team have been working on the renovation and conversion since the beginning of 2023. Through free use, an inviting story and exciting puzzles, participants aged 16+ in a group of 3-5 should have the opportunity to reflect on the topic of the climate crisis and learn climate-friendly behavior.

This thesis will present the creative design process of one piece (puzzle) for this specific educational escape room. The challenge consists of developing, planning and physically implementing an interactive game for the educational escape room.

For convenience, the words escape room are abbreviated as ER and educational escape room as EER.

Figure 1 - Airstream RV at the UT campus

Chapter 2 - Background research

In order to accomplish the above-mentioned task, meetings with the client were held to understand the vision in detail. The result of the information received was the following design question.

How can you raise awareness of the issue of climate change in a playful way by playing a piece in an educational escape room?

From this design question and the information received about the project, the following main research question was formed.

Research question

How to design a piece for an educational escape room with the topic climate change with the goal of raising awareness and learning motivation about the topic?

In addition, and refinement to the main research question, four sub research questions arose over the course of the research.

Which characteristics of existing escape rooms and educational escape rooms are valuable when creating an EER piece in the context of this project?

How to design the puzzle so that the desired topic and theme of the EER are recognisable?

Which game characteristics must be taken into account when creating it and how can they be integrated into the puzzle?

Which technical options contribute positively to the desired gaming experience and how can they be integrated?

Since the creation of an EER puzzle has not been discussed in detail during the Creative Technology program and in order to approach the task professionally, background research and interviews are carried out on the following questions.

1. What is an educational escape room?
2. Which learning theories are used in the design process of an EER piece?
3. What types of learning objectives can be taught with an EER about climate change and climate-friendly action?
4. What possible behavioral changes can be achieved through an EER on climate change?
5. How can technology be used to enhance the experience in an EER?
6. What are the design possibilities for a piece in an educational escape room in an Airstream?

The aim of the background research and interviews is to provide a list of requirements for the topic, game and technology of an EER piece.

2.1 What is an educational escape room?

For several years now, EERs have been used as a learner-centered activity to playfully support the learning of objectives at any educational stage from primary to professional level [1]. Wills et al described the use of an educational escape room as a way to convey a learning objective in an engaging way on a playful basis [4]. Derived from the game-based learning theory, the engaging and immersive experience triggers motivation to learn. Koivisto et al. call gamification for learning a next-generation method because humans are “hardwired” to like playing games [5]. Fotaris described an EER as a collaborative playful learning experience that was specifically developed for acquiring skills, acquire knowledge or changing behavior [2]. Escape rooms are creative and different, it is not possible to break it down to a specific use case. What is certain, is that EERs are a concept in which many use cases find a way to convey learning objectives. The advantages of an EER are also the acquisition of so-called skill type benefits. These are explained in detail in section 2.3.

Use cases/ state of the art of EERs

The largest area is school education. Here, EERs are used to deepen curriculum content [3]. Other use cases are medical education [21,20,43], language teaching [28], cryptography and computer science [22], to get to know institutional services [23,24], design skills [25], biology [26], physics [27] or simulation of real world situations [36]. It is clearly evident that the area of use for EERs is very large. On the one hand, this offers a lot of creative space for innovative learning processes and, on the other hand, the opportunity to refresh current methods. Another advantage of an educational escape room is that it can be used at different stages in the learning process. At the beginning to create an introduction to a topic [21], in the middle to explore the content learned at the beginning [36] or even as an evaluation at the end of a course [37]. Most articles cover the time of use at the beginning or in the middle of the learning process. The knowledge query as an evaluation at the end is still very unexplored.

Auto ethnographic escape room visit

In order to strengthen our understanding of the user perspective and the general process of an escape room, we as a team visited the escape room "Enschede Airport" from "Escape Enschede". With this visit we hoped to gain insights into the process and the emotional state of a participant that may not be reflected in the literature.

In a 15-minute introduction, information about the story, the puzzles and the process were given. Walkie talkies were also distributed to the groups to be able to communicate with the gamemaster during the games. The special feature of this room was the competitive structure, as the room has been built twice so that players can compete group vs. group against each other. The group with the most completed puzzles at the end of the 60 minute time wins. According to the gamemaster, the open puzzle structure allows starting and ending with any puzzle. There are also puzzles of every difficulty level to give experienced and unexperienced participants an unforgettable experience.

In terms of decoration, the room was kept rather simple compared to other rooms visited during the research of the escape room in Münster. There were almost no objects in the room that served as decoration. A background audio that mimicked incomprehensible conversations and wallpaper that corresponded to an airport waiting area acted as support for the story.

There was a large selection of puzzles in the room. The majority of the puzzle consisted of simple combination puzzles. For example, examining a magazine for headlines and generating a solution based on the answered questions. These games were in one of the suitcases in the room. The elaborately crafted puzzles that required interaction with one or more players are the most memorable. For example, the security puzzle in which you, as an airport security employee, have to scan suitcases and find illegal items. A puzzle that was externally well designed, but was not suited to the target group, is the music puzzle. For this puzzle, songs from different years had to be connected to the origin year using cables. Unfortunately, due to our age, we did not have enough knowledge to create the right combinations. Here the father of the family in the other room had a clear advantage, as he completed the puzzle within 5 minutes.

2.2 Which learning theories can be used in an EER?

Fundamentally, EERs are based on the **constructivist learning theory**. In simple words: “learning by doing” [31]. Unlike lecturing, the student plays a fundamental role in the knowledge acquisition process. The learning process of constructivist learning theory consists of inquiry, reflection and analysis [32]. Inquiry is the active engagement with the material. Reflection offers the students the opportunity to think and reflect on the facts recorded. The analysis helps in the process of retaining the information recorded. This sequence of confrontations with knowledge occurs in most EERs. The EER itself offers active engagement with the topic and the

information. Unlike commercial escape rooms, after the active phase there should be a reflection phase in which the students reflect on the scenario played in order to separate the entertainment factor from the knowledge [30,19]. This phase is called the debriefing phase. Here the player has the opportunity to apply what has been learned without any time pressure or to find out more about the topic in detail.

Flow theory

A frequently mentioned theory in the ER literature is the **Flow theory**. This theory describes the state in which a person experiences the qualities of concentration, control and joy, which allows them to completely immerse themselves in the task [6]. This theory was explained by M. Csikszentmihalyi in 1991 [7]. In an educational escape room, the structure of the puzzle can guide through the learning objective by increasing in difficulty, which makes it easier to enter the “flow state”. The puzzles should be ordered according to the level of difficulty to make it easier to enter the “flow” state [30]. By building up from easy puzzles to difficult puzzles, the player is motivated with small successes and rewards that can triggers emotions.

Social constructivism

Social constructivism describes learning knowledge through interaction with other people. Collaborating with others makes it easier to absorb knowledge[8]. This approach has often been associated with EERs because, as already discussed, teamwork and communication are important aspects in solving an escape room [9,10]. Fotaris strongly connects this theory with the pedagogical perspective on EERs [2].

Gardner's theory of multiple intelligences

This theory states that there are multiple types of intelligence rather than one intelligence as a whole [11]. In a group activity like an EER, participants come together who often have different strengths and weaknesses. The puzzles in an escape room usually have a specific approach to solving them, which require a certain skill. It can therefore be advantageous to enter an escape room with a mixed group of different ages and skills. The target group for which the escape room is designed therefore plays an important role in creating the puzzle.

Self-determination Theory

The SDT states that individuals with the characteristics of autonomy, competence and relatedness to others experience a higher motivation to learn. Game based learning approaches

that make these features possible can enhance the learning experience [33]. This theory that Ryan et al described here applies to the properties that are taken into account in the design processes of EER puzzles. A study by De Meyer et al. observed 56 teachers and 700 students to examine “controlling behavior” and the impact on students’ learning behavior. The results have shown that a strong controlling attitude on the part of the teacher triggers pressure on the students, which is counterproductive for their learning behavior [34].

Game based learning theory

Game based learning can be described as a game activity that specifically strives for a planned learning outcome. Not only can GBL improve players' cognitive development, but it can also promote motivation and engagement. The advantage of GBL is that it can contain multiple forms of engagement, creating a learning experience that is unique compared to traditional learning methods. Figure 2 shows the structure of the design framework of game based learning [49]. The design elements of the GBL provide a basis for application to an EER design process.

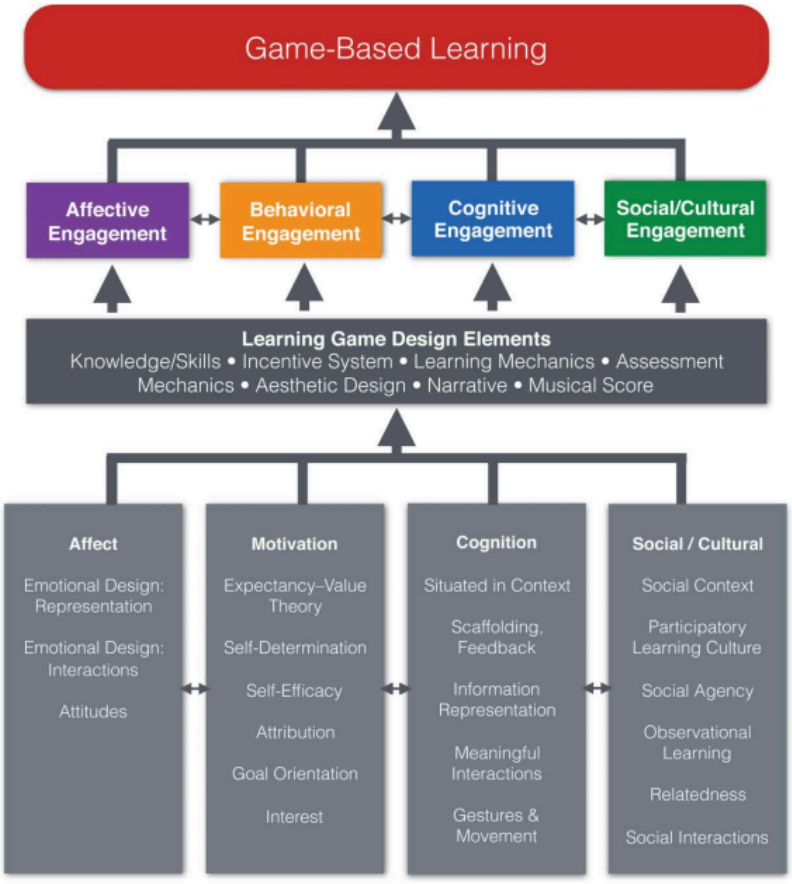


Figure 2 - GBL design framework

2.3 What types of learning objectives can be taught with an EER about climate change and climate-friendly action?

Learning objectives

The learning objective is knowledge, a skill or a behavior that is to be taught using an EER. It depends on the main topic or curriculum of the creator's aim.
There are three categories into which the learning objective can fall [2].
1. Playful learning
2. Acquisition of skills/ knowledge
3. behavior change

The most frequently mentioned objectives in the literature are:

1. **Critical thinking**: By motivating students to analyze clues and to find the combination, they are forced to think critical about the given information.
2. **Teamwork**: Most EERs are designed to be solved in a group setting. Only when the collaboration works, the puzzles can be solved.
3. **Time management**: By setting a time limit for solving the puzzles, the skill will be enhanced.
4. **Problem solving**: By solving puzzles and overcoming challenges the skill of problem solving will be enhanced. The player is forced to think about a problem from different perspectives.
5. **Communication**: Most EERs can not be solved alone. By communicating about a finding or a code for example, the teammates have the possibility to incorporate the information in their search.
6. **Knowledge**: By implementing the knowledge that is to be learned into puzzles, the player is forced to deal with the topic.
7. **Stress management**: By implementing time, the player learns to work and think under pressure.
8. **Creativity**: For a lot of puzzles logical thinking is not enough. Some are only solvable when using thor creativity.
9. **Ability to change**: As in a good movie, things can change fast. The player learns to adapt to the new situation.
10. **Detail**: Puzzles can need the smallest hint to be solved. By scouting the room, the player will learn to concentrate on details.

Gordon et al. described this skill as “leadership skills” [35]. Cruz described these soft skills as “21 century skills” [28]. Fontaris categorized these benefits in his handout paper for this year's ECGBL23 at UT as **Intrapersonal**, **Interpersonal** and **Academic** (figure 3).

Intrapersonal skills	**Interpersonal skills**	**Academic skills**
Perseverance Time management Increased confidence in critical thinking and decision-making Problem-solving Attention to detail Cognitive flexibility Creativity and innovation Increased self-esteem Cultural understanding and appreciation Spatial reasoning	Communication Teamwork and collaboration Improved ability to delegate tasks and work as a team Community building: learning about your own and other people’s strengths Appreciate the diversity of thinking strategies encountered in any group of people	Reading comprehension Preview and review material Stronger emotional connection to curriculum material Higher rates of retention Competition can pique motivation Opportunity for feedback and practice Entrepreneurship: students could build a business around this

Figure 3 - Fontaris [30]

Debriefing Workshop

Debriefing is a fundamental step in the learning process with EERs. Long-term preservation is not a prerequisite simply by confronting knowledge. Only through reflection after completing the escape room the player has the opportunity to connect the perceived impressions and experiences with the learning objective [19].

The ”Escapeclimatecrisis” EER by Mr. Heinrich and his team will also offer a workshop which will take place after completing the EER. Here, participants have the chance to learn reflectively about the topics they have identified while playing.

2.4 What possible behavioral changes can be achieved through an EER on climate change?

There are many approaches to behavior change that are possible through EERs with the topic of the climate crisis. This is possible by motivating attention to the topic, the understanding of the topic and the responsibility for action. The following are possible behavior changes that can be achieved by an EER about climate crisis:

1. Raising awareness
By providing information about the causes, consequences and problems of climate change, it is possible that awareness of the topic can lead to climate-friendly thoughts among users.

2. Empathy & Global connection
As Stephan Heinrich described it, emotions are a way to show importance. Empathy for other people in the environment, animals and the world can trigger a behavioral change.

3. Trigger curiosity
Due to the forced exposure to problems in an EER, the user is forced to deal with a topic. This can trigger an interest in the topic and encourage them to want to know more information about the topic after the EER and the workshop [2].

4. Learning by doing
As the constructivist learning theory says, learning by doing is a possibility of knowledge acquisition. If a puzzle in an EER requires climate-friendly action to be solved, it is possible that the user will adopt the action into their everyday life. This behavior could be saving water, separating waste or saving energy [9,10].

5. Team building
As already mentioned in the learning objectives, teamwork is one of the most important components of solving an escape room. By dealing with the problem together and solving it together, the player can connect a sense of community to the topic. This can have a positive effect on understanding the global problem of climate crises [2].

6. Commitment

Since the climate crisis is a problem that can not be changed immediately, it is important to show commitment. In the best case scenario, the EER is so well designed that the players takes the topic home with them and tell friends and family about it. This commitment is very important on a topic like the climate crisis.

7. Decision making

Decision making is one of the most crucial points in tackling the climate crisis. If everyone in the world switched to a climate-friendly decision-making system, they would quickly see an improvement in their circumstances. Be it taking a bike instead of a car or going to the Dutch Sea instead of a 20 hour flight to Thailand, these are all things that you can choose for yourself. An EER can bring climate-friendly actions closer and present opportunities that are more climate-friendly than what you may have been used to since childhood [46].

2.5 How can technology be used to enhance the experience in an ER?

The first area of application is the atmosphere. Since escape rooms often have the goal of taking the player into another world/story, there are many technical options to increase the feeling of realness. To intensify the feeling, the senses should be stimulated. On the one hand, the sense of hearing. Using music and sound effects like those we know from films or video games, it is possible to create a background noise that makes it much easier to imagine the desired atmosphere. This method was used in the escape room “Team Escape” in Münster that I visited. The room imitates a Maja temple and features noise, bat fluttering and ancient music to enhance the feeling of being in an actual temple. The escape room in Enschede that I visited with my team was set at an airport. Here, conversations, aircraft sounds and announcements from the flight staff were used as sound effects to reinforce the feeling of the airport even though you were on the 5th floor of an office building. Depending on which objects are using in a puzzle, appropriate sound effects can enhance the authenticity of the situation.

Another sense that can be stimulated to improve the atmosphere are visual impressions. The lighting in a room can have a strong influence on the perception of the space. The maya temple room mentioned above was very dark due to the lighting and players had flashlights to illuminate the surrounding area. This has the advantage that the participants first have to explore the room and do not see all the details at first glance.

Light can also bring life into the puzzle, for example a machine seems more real when it flashes, even if it is actually just made of wood.

However, technology is not only there to influence the atmosphere but can also help with puzzle design. As mentioned above, there are many different types of puzzles, ranging from non-technical to highly technical. Through the interviews with the target group who had just completed an escape room, it became known that players feel euphoric when things happen automatically. The participants called it “Magic feeling”. It was based on a puzzle in which a door opens automatically and sounds are played.

Sensor technology in particular offers a great variety of possibilities to detect movement, sound, light and other types of interactions and to carry out a reaction based on them. This will also be the focus for the final puzzle that will be developed.

Other types of technologies that can be considered for an EER include online/VR escape rooms. These have the advantage that only a computer is necessary to play the room. Especially for application areas and organizations that have few financial resources for the development and implementation of an EER, this can be a cheap method to offer a playful learning opportunity.

2.6 What are the design possibilities for a piece in an educational escape room?

How to design an EER

In principle, there is no prescribed target group or theme for EERs. It is up to the designer to select a target group and design accordingly. However, because escape rooms are a very new approach to learning a learning objective, they are often designed for younger generations who already have experience with game based learning and game technologies. Ishak et al describes the so-called GenZ as “multimodal learners" [13]. Multimodal learners can absorb information in many different ways. For example visual, audio, reading or writing. An escape room is therefore ideal for this type of learning, as the design process allows many different ways of transmitting information.

According to Fotaris [14], these 9 stages (figure 4) are crucial for the creation of successful EERs. This design process, created specifically for EERs, also offers a repeating cycle and idea finding implementation and evaluation and reflection for the continuous improvement of the product.

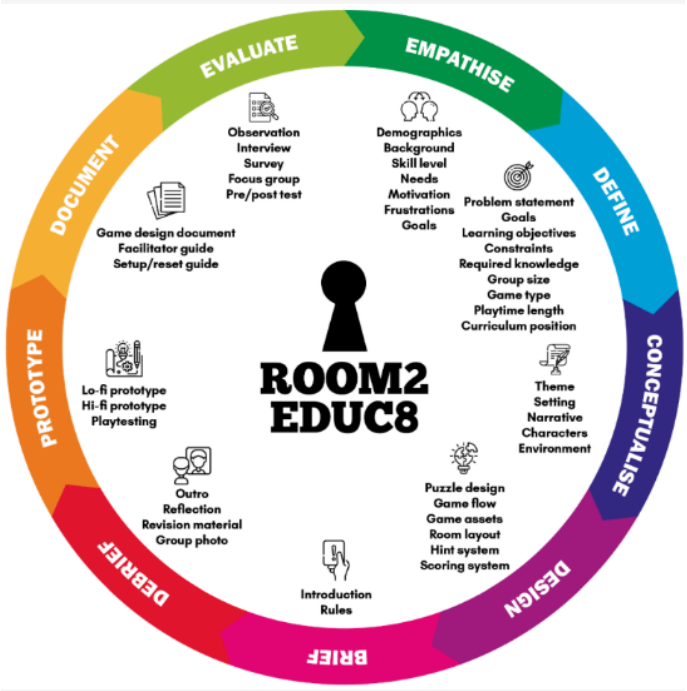


Figure - **4** Room2Educ8 framework [14]

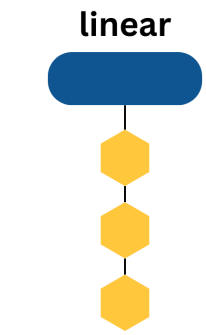
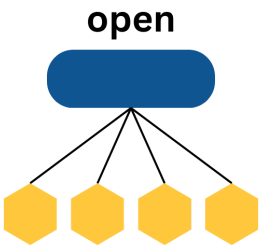
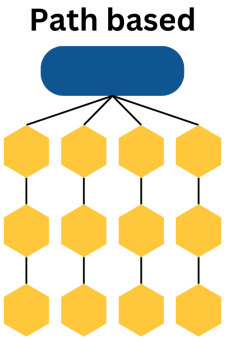
This Cycle structure is a widespread approach in the creation of creative solutions. Mader et al. also has a very similar design process. This approach has been used for years at the University of Twente in the field of creative technology [15]. However, this is not only designed for EERs but for multiple creative design approaches.

Chosen design process

The chosen design process for this project will be that of Mader et al. This design process is chosen because although this EER piece is played in a series of puzzles and a given story, the design process of the individual puzzle of this paper is standalone. A detailed description of the design processes used can be found in Chapter 3.

Puzzle design

In order to design and build the individual puzzles, the structure must first be created. The three most frequently mentioned structures are 1. the linear structure, 2. open structure, 3. path based structure.

 Figure 5 - Linear puzzle structure	Linear structure Here the puzzles are built on top of each other in a linear order. Only by solving the first puzzle is it possible to solve the second puzzle [38;30].
 Figure 6 - Open puzzle structure	Open structure The order is irrelevant. The players can start wherever they want and reach their goal [39;30].
 Figure 7 - Path based puzzle structure	Nicholson believes that linear puzzle build provides better structure of the content and nonlinear structures give the player more control over the experience[16]. This is important when the learning objective is progressive and understanding becomes important step by step.

Challenges for designers

As in any production, the budget is a crucial point when creating a product. This presents a hurdle that can change the question of implementation. It can have a big impact on how immersive an EER is [41]. Eukel et al., due to the financial possibilities, built a digital instead of physical space [42]. They also describe the problem of the premises. Almost every organization has the opportunity to make an entire room available for this purpose.

Security also plays an important role. Depending on the EER, people get locked up in a room. The designer must be able to guarantee that safe evacuation is possible in the event of danger, such as a fire. This happened in Poland in 2019 and should be the highest priority when selecting premises.

Another challenge during the design process is determining the right difficulty level.
The choice of difficulty is so important because, on the one hand, if the level of difficulty is too high, the puzzle cannot be solved by all participants. As a result, the success rate is not 100% and therefore participants who do not manage to solve the puzzle have no chance of learning the learning objective. It is also important to aim for a success rate of 100% for the puzzle, as the players will not receive the solution that is necessary for the further course of the game. Frustration can also arise if the players cannot complete the puzzle. In the worst case, this could lead to demotivation to participate in the workshop, which goes against the client's goal and design question. On the other hand, a puzzle that is designed too easily is not an advantage, as it can cause boredom among the participants.
To determine the difficulty, as in the cycle model by Mader et al. user tests will be carried out [14,15,43].

2.7 Interviews with the target group

2.7.1 To improve the properties of a puzzle, the target group for which the puzzle is being designed is interviewed. In this case, the target group describes the group of people who have interest and experience with escape rooms, not specifically **educational** escape rooms.

The following topics were of interest during the interview:

- Liked and disliked characteristics of the ER
- Experience in the room (atmosphere, sound, light)
- Difficulty level of the room

A complete list of the questions and the answers can be found in the appendix under point 1.
Two groups of interviews were conducted immediately after successful escape from the ER. The room played was a commercial escape room in Münster Germany called "Team Escape".
Group 1 consisted of 5 people. Group 2 of 11 people.

A structured interview with 6 questions was held. Each of the participants have previously read the information brochure and signed a consent form. Both documents can also be found in the appendix 3. The process was approved by the ethics committee of the EEMCS Faculty of the University of Twente. The participants' answers were anonymized.

The answers help to understand the interests of the target group and to design interactive puzzles based on their wishes.

2.7.2 Results Group 1

Group 2, 5 people, Room Blood Diamonds
Context: In this room, a team of a maximum of six players compete and have to try to get into the secret vault in order to steal a diamond. You first have to find clues in the office in order to open the secret door.

Question 1: Which elements or details in the ER did you like the most?

Multiple participants answered that automatic changes in the music in the room are perceived as positive and exciting. The music changed depending on the tension of the storyline and progress in the room to enhance the experience of the Diamond Heist. This is an important point in the design process as it appeals to one of the senses that can create tension. A good sound design of a puzzle can enhance the experience. Another aspect that was well received were unexpected events. In the participants' room there was a hidden second room behind a bookshelf. By incorporating unexpected elements you can create surprise and excitement. Hidden elements can be an interesting addition to the puzzle. A technical puzzle that was described as very interesting was blinding cameras with flashlights. For this purpose, LDRs were installed in the cameras and the increased brightness did not trigger the alarm. The participants had the feeling of being part of a real heist crew. So-called puzzle chains were also referred to as positives. The participants said that the chain reaction of solving a puzzle gave excitement and motivation to solve the next puzzle. This gives a kind of magical moment in which many things are triggered due to an input from the players.

Question 2: Did you like the atmosphere of the room? If yes, why? If not, why?

According to participants, the design of the room ensured that the storyline felt real. Both rooms were decorated very story-like.

The requirement "Puzzle fits in the storyline" is taken into account in the design process in order to create a suitable atmosphere.

Question 3: Was there anything in the room that you would improve?

One negative point that the participants noticed was that any objects that were glued directly implied that they did not belong to the puzzle. It made the players realize that it was an escape room and took them out of the experience.
Another participant called the loud beeping of the safe annoying. However, it was a deliberately annoying sound because it was supposed to imitate an alarm system.

The requirement "Puzzle feels realistic" is taken into account in the design process to create a suitable atmosphere.

Question 4: How would you rate the difficulty of the room on a scale of 1-10? (10 impossible to solve)

All participants have chosen between 6 and 7. They said that it was not too easy, but there were also puzzles where they needed help from the gamemaster. This fits with the statements about the level of difficulty mentioned in the background research. It should not be too difficult so that the player feels disappointed, but it should not be too easy so that the player gets bored.

The "Difficulty Level" requirement is taken into account in the design process in order to design an appropriate strength. This requirement will be tested in the evaluation phase. The aim is a level of 7 on a scale of 1-10.

Question 5: Were there moments when it was important to work as a team?

The participants' response was clear. They said that it was important to work as a team at any time. Teamwork was required, especially for tasks such as blinding several cameras at the same time or communicating the safe code between the two rooms. These statements fit well with the background research, as they confirm that teamwork and collaboration are an important part of an ER. Particularly in EER, it is important to integrate teamwork, as the learning effect for everyone can only take place if everyone is involved.

For the design process this is an important requirement to ensure a learning effect for all participants in the EER.

Question 6: What was your opinion on the gamemaster's advice & hints?

There were mixed opinions among the participants in the group interview. Some thought it was good to get a lot of hints because it meant they had a faster flow of the game and more success, others thought that the hints came too early and they would have preferred having more time to think about the solution themself. This is an individual assessment. Depending on the skill level and the willingness to solve the puzzle yourself, it can have a positive or negative effect on the players. The players who liked getting hints found it positive and liked that they were permanently displayed on a screen.

During the design process, a list of possible clues from light to strong will be created, which makes it easier for the game master to give the right clues for every situation in the puzzle. This will not only help the gamemaster, but also help the player by getting the right strength of a hint at the right stage of the puzzle and prevent a feeling of disappointment.

2.7.3 Results Group 2

Group 2, 11 people, Room: Temple escape

Context: For these rooms, two teams compete against each other in an identical room. The theme is about a Mayan pyramid in which puzzles have to be solved in order to escape.

Question 1: Which elements or details in the ER did you like the most?

Participants in this group also described automatic events as very cool and interesting. In this room, compartments in the wall open with input of the players. In addition, a golden altar comes out of the ground and the final door opens by itself. All these automated events combined with the Maja Temple theme created a magical atmosphere. So the chain reactions are addressed again, which are like “fireworks”. The sound design was described as very realistic. One participant said it was like being in a real temple. A point that was not addressed by group 1 was the tension. The participants described this as very exciting, like in an action film, where tension is low at the beginning, but the more puzzles are solved, the tension increases. Since this thesis covers the design process of one puzzle in a series of puzzles for the EER, this information will be passed on to the design team.

Question 2: Did you like the atmosphere and if so why?

The atmosphere was described as very real and consistent. This implies that the temple feeling was present throughout and players were not taken out of the experience. A participant said he

felt like he was in the film Indiana Jones. This shows clearly how impressive and important the atmosphere design is.

Question 3: Was there anything in the room that you would improve?

A negative element that was mentioned was that there were too many combination locks. There were 5 locks represented in the room. Here the participants would have wished for greater variation. Since some puzzles have already been solved in the climate, I will try to choose other solutions to create a more exciting feeling. A participant mentioned that some buttons in a puzzle have loose contact. Especially in a competitive escape room where you compete against another group, it is important that the same fair conditions are created. But even in a "normal" escape room everything should work, because the player doesn't know whether it's because it's wrong or because it's broken when an input is necessary. I will pay particular attention to ensuring that the puzzle is functional and that no errors occur.

Question 4: How would you rate the difficulty of the room on a scale of 1-10? (10 impossible to solve)

The participants' answers regarding the level of difficulty were between 7 and 8. This also hits that perfect spot between too easy and too difficult.

Question 5: Were there moments when it was important to work as a team?

Due to the structure of the room, the participants were forced to interact and communicate as a team because it was dark and they only had flashlights and light lighting to be able to move around the room. They said it was important because when you found a lock, another person had the code for it ready.

Question 6: What was your opinion on the gamemaster's advice & hints?

Since the participants played against each other in two rooms, but there was only one gamemaster for both rooms, it was impossible to give the hints to the teams at the same time. The teams also did different puzzles, which also made it impossible to give out clues at the same time. The participants wanted to have one gamemaster per room, as they sometimes had to wait for an answer because the gamemaster helped the other team. However, this is not relevant to this EER.

2.8 Interviews with the client

2.8.1 Approach

In order to meet the requirements and wishes of the client of this bachelor's thesis, interviews were carried out with the client by Arthur von Torre. These were also semi-structured interviews in which questions were prepared. This was specifically about topic 1. which details of the escape room were already planned before the bachelor's topic began and 2. which goals the education escape room should fulfill.

2.8.2 Results

The first point of the interview that is interesting for the design process is the spatial requirements for a puzzle. Since the escape room will take place in an airstream that is still originally equipped with furniture, the goal should be to integrate the puzzle into it. However, the client indicates that it is up to the designer's creative freedom as to where exactly the puzzle can take place. Next, the customer's visual requirements are clarified. The visual requirement for puzzle is the style of solar punk. It describes the reconciliation of nature and technology. There should be mechanical but also natural properties in the puzzle. These can be decorative or necessary for the solution. The desired color scheme is colors such as white, gray, green. Unwanted colors such as red or yellow should not be used unless they serve a purpose. According to customers, the focus should be on robustness because it is a moving bus and people should be able to handle the puzzles without fear of breaking them. Technical elements of the puzzle should not be accessible to the player to minimize the risk of braking.
The customer's expertise lies in climate communication and he therefore clearly describes the crisis as a "communications crisis". Accordingly, the design process should work with emotions and excitement in order to create a lasting experience. His wish would be “prefer fewer facts and more motivation and fun while playing.”
Another wish of the customer was to design the puzzles in such a way that they could be repaired if something breaks. For this purpose, the circuit plan, code and accessibility of the electronic components are crucial. The goal is to actively use the bus for 3-5 years and the puzzles should be designed accordingly.
Another wish was to use design options such as sound or light to integrate the puzzle into the story as well as the visual design goal in order to enable a deeper understanding of the experience. The client made the following additional claims regarding the puzzle. It should focus on entertainment but not lose the main topic of the climate crisis. Here it is possible to focus on a sub-area of the climate crisis.

2.9 Interviews with ER designer/Gamemaster

Expert interview:

2.9.1 Approach

In order to understand the designer's point of view, I conducted an interview with a game designer for commercial escape rooms. It was a semi-structured interview, because answers are difficult to predict, especially in an expert interview, a semi-structured interview offers the necessary freedom to address the unforeseeable things. A list of questions has been prepared for this purpose and can be found in appendix 6.

2.9.2 Results

Gamemastering

The first topic of the interview was “Gamemastering”. The interviewed expert works in an escape room in Münster and therefore has a lot of experience with managing an escape room. First he explained the tasks of a Gamemaster. These were, on the one hand, an introduction at the beginning of the escape room in which the topic is already explained as well as important information that is necessary to solve the escape room. The rules are particularly important here. Two rules that are appointed provide the basis for an important requirement for an escape room puzzle. The first rule was: "Everything that my 12 year-old niece cannot lift or move should not be lifted or moved." This rule serves to protect the space and limits the player. It implies that it is not necessary to move furniture, for example, to solve the puzzle. This implies the requirement of robustness for the design process of an ER puzzle.
On the other hand, the most important task, according to the expert, is to keep up to date with the players' progress. This is crucial for being able to give hints and players support. This happens through hints that the gamemaster can send into the room from outside through some form of communication. The expert gave examples of how this can happen. On the one hand, a direct connection can be made using a cell phone or a “Walkie talkie”. Another method is a display onto which the gamemaster can send images or hints. Figure 8 shows the gamemaster's command center. On the left side a surveillance system with 4 different angles of the room can be seen. The use of the cameras is to check the progress of the players and also to detect emergencies. The headphones provide the necessary audio. On the right you can see the information system. In the expert's ER, ready-made instructions can be sent to the ER screen via drag and drop. However, these can also be personalized. In addition to the text, pictures of important objects can be sent and act as clues. The task of a clue in an ER is to

provide help to the correct solution if the player has a wrong solution or gets stuck. The gamemaster's opinion about hints was that it takes a certain feeling to recognize which hint helps to move forward. According to experts, the key here is not to reveal too much so as not to deprive the players of the chance to complete the puzzle themselves but enough so that no frustration arises.

Figure 8 - Escape room Gamemaster setup

Puzzle design

On the subject of puzzle design, the expert said that the connection to story and context is of most importance. The whole ER is built around a story and the puzzles should reinforce this. He also added that the position and order of a puzzle is important. They should be sorted from easy to difficult and from less exciting to very exciting if the story context allows it. Finally the expert talked about the reward system of a puzzle. By solving a puzzle the player should gain a certain advantage. This can be in the form of clues to the next puzzle, change in music or points.

2.9.3 Approach

In order to understand the designer's point of view, an Interview was conducted with a game designer for commercial escape rooms. It was a semi-structured interview, because answers are difficult to predict, especially in an expert interview, a semi-structured interview offers the necessary freedom to address the unforeseeable things. The interview can be found in appendix 8.

2.9.4 Results

The game design expert brings a wealth of experience to the interview. She herself has already played in more than 120 escape rooms and her company has already designed several. The expert is currently studying for a master's degree in game design at a university with a focus on how escape games can advance the educational sector. In the following I will present important statements for the project and explain how they relate to the design process. Topics that are already presented in the interviews mentioned above will be omitted.

About the design process of a game, she says that with complex topics it is important to approach the main theme piece by piece. The climate crisis is a very complex topic and it is difficult to compress the entire concept into a 60-minute EER. Therefore, the puzzle ideas will focus on some components of the climate crisis such as waste separation, fossil fuels or green energy.

Another point in the design process is understanding the location. Before you go to the ideation phase, you should know the possibilities and limitations of the area of the puzzle in order to design accordingly. These could be lighting conditions or power supply.

According to experts, the main point of the design process should be the core question. This should be answered after successfully completing the room. It is crucial for the interaction of the individual puzzles, which each influences the answer. Another point that is also confirmed by the literature is prototyping an idea. According to experts, it is crucial for evaluating and improving the puzzle. A designer will never have the same angle of view on the product as a tissue tester who sees the product for the first time.

A crucial point for a successful experience in an ER is manipulating the player's feelings. The goal here, according to experts, is to give the player a "roller coaster" of emotions. It is important to plan which emotion should be created at which point/puzzle. She criticizes the fact that in EERs, from her experience, solving the puzzle in the right way is not enough to create a lasting experience.

Since it is a moving trailer, more attention should be paid to its robustness, as transporting EER does not normally occur. The expert also mentions that ERs usually work with a second roof under which you can hide cables. This could be a problem because the Airstream is a very narrow space. If cables are freely accessible, players can accidentally damage them. Finally, she gave her opinion on the future of educational escape rooms. Through a conversation with a primary school teacher, she came to the decision that EERs could be used as a perfect learning tool in primary school, where learning soft skills is becoming more and more important. Students

who are not normally the stars in the classroom get the chance to share and apply their knowledge in a way other than face-to-face teaching.

2.10 Conclusion of the background research

Educational escape rooms are part of future learning methods. They are made for the new generation. Multi modal learners have a motivating and exciting method to learn knowledge and skills. In theory, the literature has shown that EERs proves to be a varied and interesting alternative to frontal teaching. They can offer advantages not only in the educational sector but also for companies and organizations. The studies show that they are motivating and encourage participants to deal with the learning objective.
However, it is also clear that EERs alone are not sufficient to achieve the teaching of knowledge goals. It seems as if the use case would be very suitable for the introduction or querying of a topic. Another disadvantage to consider is the cost of an escape room. Chang believes that budget has a clear impact on an ER's experience [41]. Also to note is that if it is an actual room and not one of Nicholson's room alternatives [16], it may be an obstacle to providing an entire room for the purposes. Eukel et al built a digital EER instead based on these obstacles[38]. Sustainability also plays a role when deciding to design an escape room. After completing the room, the puzzles are known to the participant and therefore exclude the possibility of reusing the room. Lastly, if an organization takes the step to build an EER despite the many obstacles, it requires a certain level of game design knowledge to create a successful and immersive EER. To do this, you either have to hire a company or invest a lot of time in research.

The advantages and disadvantages of an EER are difficult to weigh. There is definitely a legitimate use and presence for EERs and the associated literature. Educational escape rooms are still very new in the educational sector and future research is needed into the extent on how long-lasting knowledge can be taught. Some of the hurdles mentioned above will be solved in the future and some already have been. Be it, for example, the use of actual rooms. The alternatives EscapeBox or VR ER mentioned by Nicholson and Fortaris offer ways to get around this. With the development of technologies such as VR, it will be possible in the future to create cost-effective EERs and perhaps even expand the reusability of a room by changing puzzles. The studies show that there is a great interest of the participants in EER and that it has a positive effect on the learning experience. The chosen requirements for the EER piece identified through the background research can be found in chapter 4.

Chapter 3 - Methods and Techniques

The aim of this chapter is to present the method used in order to improve understanding during application.

Mix and Match Method Shell

The mix and match method is used for the ideation phase. This method combines concepts, ideas, elements, technologies or approaches. Every new constellation can create a new perspective and idea. There are 6 steps to keep in mind when using this method [47].

1. Starting point
   The first step is to identify the elements, ideas, concepts, etc. that you want to combine. For this purpose, a literature review on the state of the art on the topic is recommended.
2. Usually in note form, the elements, ideas, concepts, etc. will now be written individually on cards.
3. Combine
   Now you have a variety of possible combinations in front of you. In this step, the cards from the different categories are combined with each other to create concepts.
4. Improvement
   The combined idea will not be perfect from the start, but it should lay a foundation on which to build. Therefore, this method requires iteration to finalize the idea.
5. Testing feasibility
   For this step, the combined raw ideas are tested for feasibility. Feasibility is intentionally very broad, as it can be technical, ethical, financial, etc. feasibility that decides whether the idea is implemented or not.
6. Testing
   The ideas of the above steps can then be transformed into prototypes and can be included in the design cycle.

Design process

As already mentioned in chapter 2.6, the creative design process by Mader et al. will be applied. For a detailed overview of the design process from Mader et al. I recommend the associated paper REF No.15. To understand this design process, a summary and visualization in figure 9 follows.

In summary, the process consists of four main phases. In the **ideation phase**, initial ideas are created with the help of the design question and, for example, the tinkering method.
The second phase is the **specification phase** in which the ideas from phase 1 are used to create prototypes that undergo an evaluation. The third phase, the **realization phase**, is characterized by the fact that the final idea is technically implemented by first decomposing it.
The **evaluation phase** is the last of the four main phases, but not the end of the design cycle, as it is, as the name suggests, a continuous cycle of improvement. In this phase, the final prototype is evaluated using tests and, if necessary, improved through backtracking. By constantly improving and testing the prototype, design decisions are evaluated piece by piece and a satisfactory product is the result.

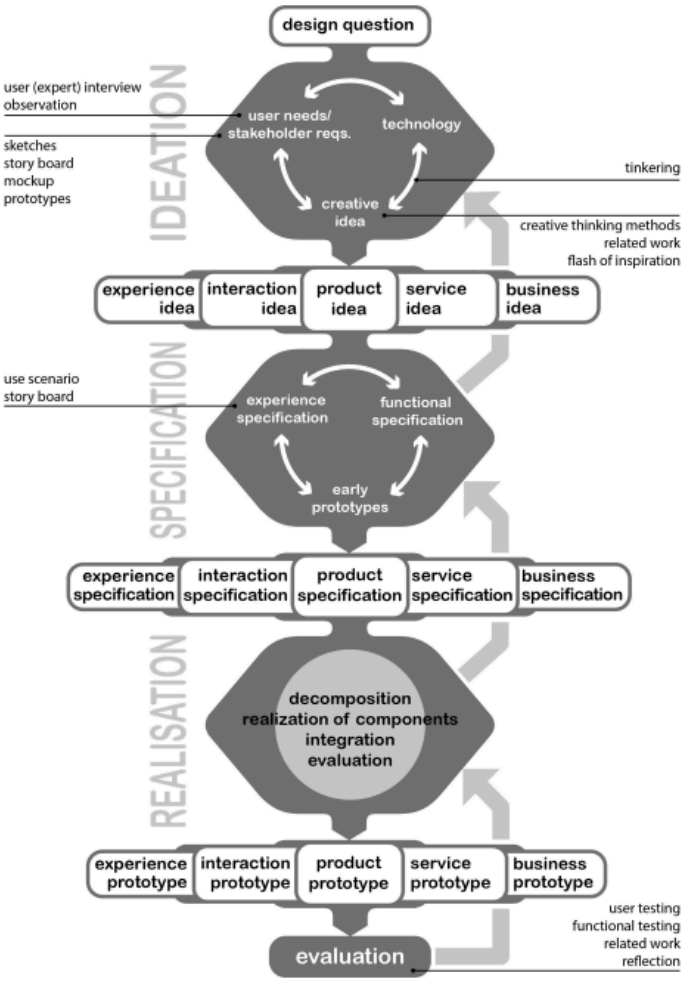


Figure 9 - Design process, Mader et al. [15]

Chapter 4 - Ideation

Based on the design process of Mader et al. This chapter will present the creative ideation process of finding possible puzzle ideas for the given limitations of the project using the mix and match method.
To begin the ideation process, the client's design question is required and the puzzle requirements identified through the background research and interviews. In addition, possible learning objectives related to the climate crisis that could appear in a puzzle were created.

Learning objectives connected to climate crisis

An educational escape room about the climate crisis should cover various learning objectives in order to develop and convey an understanding of the problem. Since the climate crisis is a very complex topic, it is almost impossible to cover it completely in a 60 minute EER. Through the subsequent workshop and the hopefully conveyed motivation on the topic, the user will learn how to act climate friendly and how to prevent negative decision making in connection with the climatecrisis. The EER with the learning objectives “problem”, “understanding” and “solution” offers a solid basis to increase motivation.

1. Causes of the climate crisis

The EER could represent the main causes of the climate crisis. The main causes of the climate crisis are fossil fuels, deforestation, industrial processes that lead to greenhouse gasses, waste, energy production and other causes [45].

2. Science

There are still people in the world who think that climate change does not exist, even though there is numerous scientific evidence about the development of climate change. An EER could represent scientific principles such as the greenhouse effect in order to raise awareness.

3. Species extinction

The effects of climate change not only affect people, but also the world's animals and ecosystems. An EER could present the impacts on ecosystems. For example, rising sea levels can have fatal consequences for the Netherlands. It could also represent the extinction of species and the change in biodiversity.

4. Global climate crisis

The climate crisis is not a national problem but a global problem. The EER could communicate the need for global cooperation. For example, international climate agreements.

5. Health effects on humans

To illustrate the need, the EER could illustrate the health threats and changes that are coming to us as humans. For example, it is becoming increasingly difficult for older people to cope with the heat waves caused by climate change.

6. Sustainability and energies

To address the problem of fossil fuels, an EER could educate about renewable energies and ways to integrate them into your own life.

7. Individual options for action

This is the point that could possibly make the biggest change. The EER can describe and teach climate-friendly trading in everyday life. Through many small changes from each of us it is possible to achieve big change.

Design question: How to design a piece for an educational escape room with the topic climate change with the goal of raising awareness and learning motivation about the topic?

In order to make it easier to answer the sub research questions later, the puzzle requirements were divided into three areas. The first area includes the content of the puzzle, the second area includes the game characteristics and the third area includes the technical requirements.

4.1 Final Requirements

4.1.1 Content Requirements

4.1.1.1 Theme “Solarpunk”

Solarpunk represents a future in which humanity has made the right decisions and the ecological aspect is in the priority. Visually, it has more utopian details than dystopian features. The color is mostly green, plant-based and dynamic. Stephan

Heinrich, our client, sums it up and describes it as a “friendly connection between technology and nature”. The final prototype should visually fit into the Solarpunk theme.

4.1.1.2 Story

The puzzle must fit into the existing story of the escape room.

An escape room is an experience in which you immerse yourself in a story and put yourself in a role or setting. To improve this captivated feeling, the game should fit into the story. The story is presented in chapter 4.2.

4.1.1.3 Communication of a learning objective

EERs are used to convey a learning objective. The learning objective of this EER is, on the one hand, to increase awareness of the topic of climate change and, on the other hand, to contribute to motivating climate-friendly actions. The final prototype should increase awareness of climate change and raise motivation to learn more about it.

4.1.2 Game characteristics requirements

4.1.2.1 Adaptation to the target group

Care should be taken to select design decisions appropriate to the target group. What is most important here is the comprehensibility, the level of difficulty and the educational level of the participant. The target group for which the EER is designed is 16+ years old and understands the German language.

4.1.2.2 Appropriate difficulty level

The difficulty level of an ER is very important because a puzzle that is too easy can cause boredom and, on the other hand, a puzzle that is too difficult can lead to frustration. In an EER it is even more important because not solving a puzzle prevents the player from learning the intended learning objective [2,14,16]. The level of difficulty is a very subjective assessment, as the educational level or experience with ERs has an impact on the skills required to solve it. Since the EER's target group is 16+ years old, the puzzle must be solvable for every player, regardless of experience or age. The desired difficulty level of the puzzle is 7 on a scale from 1 (super easy) to 10 (almost unsolvable).

4.1.2.3 Enjoyment

The goal of the EER is to leave a positive impression on the other players. Therefore, the client wants a puzzle that is fun to play.

4.1.2.4 Teamwork:

Teamwork is crucial for an exciting escape room, as it enhances the experience and also reinforces the learning effect.

4.1.2.5 Multisensory appeal:

An escape room offers the perfect place to appeal to different human senses. This can enhance the player's experience and make them immersed in the story. Suitable sounds or decorations can be used for visual stimulation. The use of sound is also important. Not only can background music improve the atmosphere, sound effects in conjunction with the games also have a positive effect on the experience.

4.1.3 Technical requirements

4.1.3.1 Robustness:

The durability of the escape room should play a major role in the development as long-term use can be assured and this also has no negative influence on the client and the player's experience. This is particularly important in an escape room, as players do not know what they are looking for and examine everything they find.

4.1.3.2 Easy Repairability:

If the puzzle breaks, circuit diagrams, the code and exchange parts should be made available to the client in order to guarantee long-term functionality.

4.1.3.3 Quick reset time:

In order to make the room playable again after a group has completed the game, the team/gamemaster must return moved objects etc. to their original location. In order to simplify this task, an easy reset method should be programmed/installed in technical puzzles.

4.1.3.4 Interesting design:

As a designer, you should make sure to design new, exciting things to give the player an experience that stays in their head. The interviews showed that surprising moments caused the most excitement.

4.1.3.5 Appropriate integration:

In terms of size, the prototype should fit into the Airstream and not represent an impediment to functionality, as the space itself is already quite small.

4.2 Project background

The project team started work in spring 2023. Until the start of collaboration with the student team under the leadership of Dr. Angelika Mader, the properties of the EER have already been worked on. The team has already defined the general goal of the EER. The EER is intended to draw attention to the topic of the climate crisis and motivate people to learn about climate-friendly actions. The theme “Solarpunk” was also decided and a storyline was developed. The story is about a scientist named Dr. Dorothy Hartman. She lives in the future and uses the Airstream as a laboratory. Dr. Hartmann sent the Airstream to us in the past to use it to save the world. The Airstream players take on the role of “selected scientists”.
In addition to the story, it is divided into three acts. These three acts are “understanding, courage and love”. Each of the three students participating in the project develops a main play for one of the three acts. The puzzle described in this thesis is used in the second act "Courage". What effects the act will have on the puzzle is described in the specification phase.

4.3 Mix and Match Method & Idea generation

As already mentioned in chapter 3, the mix and match method offers a creative way to find a suitable idea by maximizing the quantity of ideas.
Based on the possible learning objectives mentioned above, the topic and technical knowledge of microcomputers, categories were created and filled with appropriate elements.

Climate topics	Technology	Items
- Sustainable agriculture - Green Energy - Recycling/Upcycling - Climate - Waste Prevention - Water/water protection - Environmental protection - Behavior	- LDR - Keypad - Servo - Touchsensor - NFC - Temp sensor - Distance sensor - Humidity sensor - Potentiometer - Relais - Pieper/sound - LED - LCD - Tilt sensor	- Box - Mirror - Flashlight - Solar Cell - Laser - Water - Generate energy - Plastics - Lock - Trash - Book - Plants - Key - Cup - Glasses

Figure 10 - Mix and Match categories

Example results of the Mix and match methode:

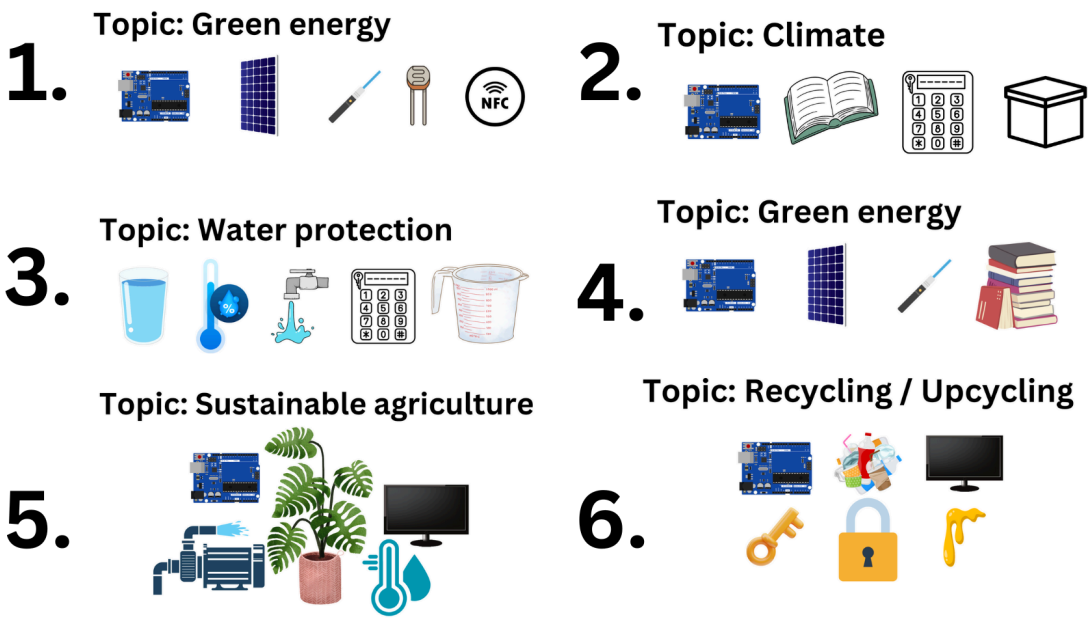


Figure 11 - Example results Mix and Match methode

Using Shell's mix and match method, 30 keyword combinations were created. Figure 11 visualizes 6 examples of these 30 combinations. Basic puzzle ideas were then formed based on these combinations. In order not to directly reduce the creative space, most of the requirements mentioned above were ignored and only care was taken to ensure that the puzzles correspond to the climate theme. The requirements will be added in the subsequent revision phases of promising ideas.

The 8 most promising ideas are presented and revised below.

4.3.1 8 Idea variations for puzzles based on Mix & Match results

Below 8 promising ideas created using the mix and match method are presented. After creation, there was a reflection on usability for this project.

4.3.1.1 **1.Idea**

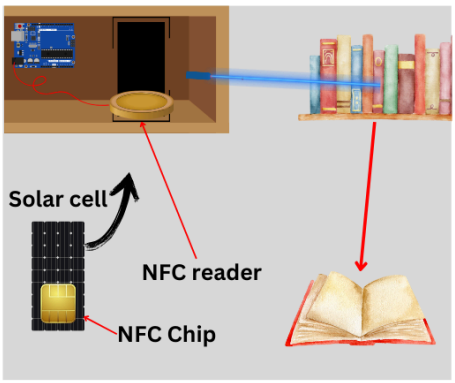


Figure 12 - Idea 1

Mix and Match: Green Energy,NFC,Book,Laser

Order of events:

- Insert solar cell
- NFC chip activates laser
- Laser points on a book on the shelf
- The book contains a clue to the next puzzle

Reflection

Idea 1 builds a series of interconnected puzzles, but upon receiving feedback, it becomes clear that there is a critical problem that could make the puzzle unsolvable. Specifically, if participants examine the books before activating the laser, it could cause the laser to hit the wrong book or an empty spot. As such, this concept does not seem suitable for an escape room.

4.3.1.2 **2.Idea**

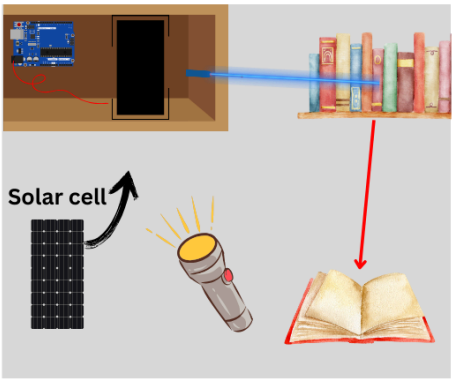


Figure 13 - Idea 2

Mix and Match: Green Energy, Solar cell, flashlight, Book, LDR

Order of events

- Insert solar cell
- Illuminate the solar cell with the flashlight
- LDR detects light and activates the laser
- Laser points on a book on the shelf
- The book contains a clue to the next puzzle

Reflection

The second idea shares the same limitations as the first and is therefore also not a fitting option for a puzzle. Additionally, since the client requires a playtime of 10-15 minutes, the time to solve this puzzle seems shorter than intended.

4.3.1.3 **3.Idea**

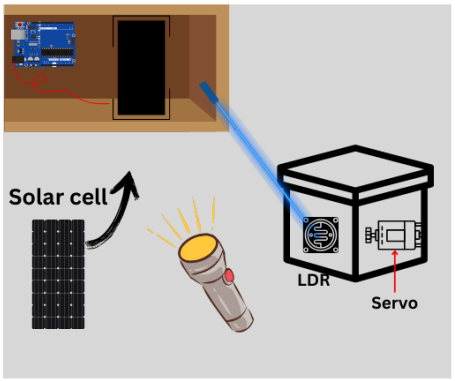


Figure 14 - Idea 3

Mix and Match: Green Energy, Solar cell, flashlight, Box, LDR, Servo

Order of events

- Insert solar cell
- Illuminate the solar cell with the flashlight
- LDR detects light and activates the laser
- Laser points on a LRD attached to a box
- The box opens & contains a clue to the next puzzle

Reflection

The third idea would fix the problem of the first two ideas. The box would not be movable and would therefore always be hit by the laser. Here too, it is important to choose a weak laser or a safe laser height to reduce the possible risk of injury.

4.3.1.4 **4.Idea**

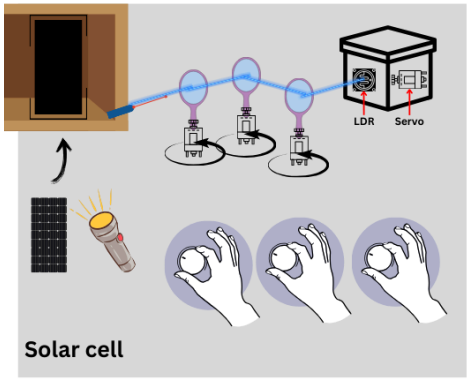


Figure 15 - Idea 4

Mix and Match: Green Energy, Solar cell, flashlight, Box, LDR, Servo

Order of events

- Insert solar cell
- Illuminate the solar cell with the flashlight
- LDR detects light and activates the laser
- players rotate the mirrors so that the beam points at the box

- The box opens & contains a clue to the next puzzle

Reflection

Idea four offers a change from the first three ideas through the ability to influence the laser. The knobs, which are distributed at different locations in the Airstream, increase the challenge of the puzzle and teamwork. The safety precautions for the laser would also be applied here. Since the lasers can only be moved horizontally, players cannot make the laser point upwards to their eyes.

4.3.1.5 **5.Idea**

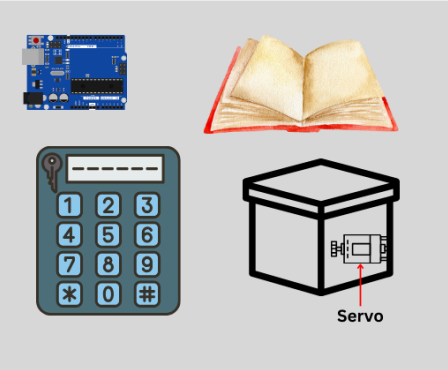


Figure 16 - Idea 5

Mix and Match: Book, Temperature, Box, Keypad

Order of events

- the player has to find the correct page in the book
- type in the temperature with the keypad
- When 4 correct temperatures have been found, the box opens

Reflection

Compared to the first 4 ideas, idea 5 has an educational focus. The fun of the game is on the second level and the learning objective, learning facts about climate change by having to find them out for yourself, is on the first place. This would be a suitable level if the reflection workshop would not exist. However, since it is offered, the focus of the puzzle should be on the fun and motivational factors in the puzzle.

4.3.1.6 **6.Idea**

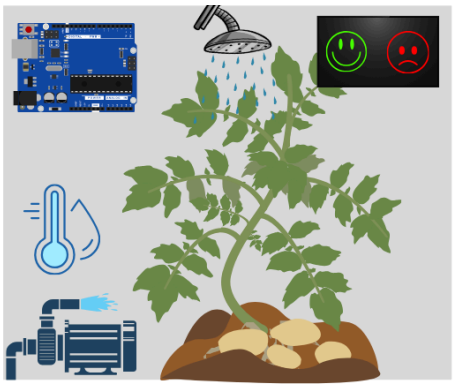


Figure 17 - Idea 6

Mix and Match: Water pump, Plant, LCD, Humidity sensor

Order of events

- the player has to find out the right amount of water for the specific plant
- use the humidity sensor to test the soil
- use the pump to water the plant

Reflection

Idea 6 shows a new topic of the climate crisis, namely sustainable agriculture. Even if sustainable agriculture is an important topic of the climate crisis, it is difficult to apply it to the everyday life of the target group. Very few people have a garden or farm where the knowledge they have learned about sustainability can be applied. To enhance the effect of the EER, a puzzle idea that addresses a tangible topic is a better solution.

4.3.1.7 **7.Idea**

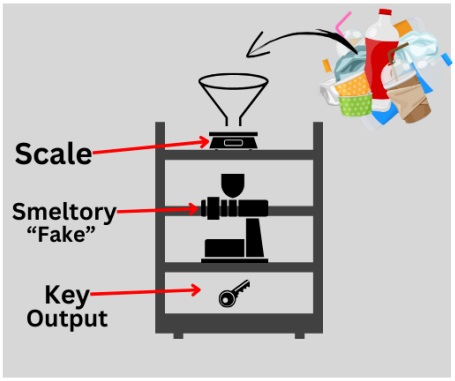


Figure 18 - Idea 7

Mix and Match: Recycling/Upcycling, Plastic, lock, key, screen

Order of events

- Find plastic in the airstream
- Put right amount in the smeltery
- Smelting animation
- Machine puts out a key for the next puzzle

Reflection

Idea 7, on the other hand, shows a clear learning effect for the player. It brings the topic of recycling closer and shows how easy it can be to extract raw materials from waste for reuse. Unfortunately, this puzzle idea offers few opportunities to integrate teamwork apart from finding plastic as a group.

4.3.1.8 **8.Idea**

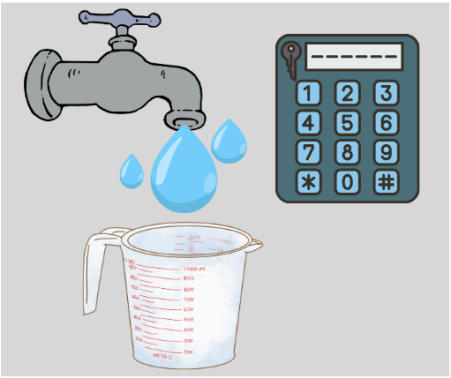


Figure 19 - Idea 8

Mix and Match: Water protection, keypad, scale, measuring cup, water tap

Order of events

- The players have to take turns filling different amounts of water
- they only have one liter at the start of the puzzle
- The last amount that needs to be filled is 999 ml.
- If it is not possible to fill the last amount because too much water was spilled, a time penalty or an information video can be played.

Reflection
The last of the eight ideas deals with the topic of water protection. There is a clearly recognizable learning objective of the sustainable treatment of water that can be used in everyday life. Unfortunately, water is a dangerous object in a puzzle. Especially when working with technology in a room with a wooden floor. Therefore, this puzzle idea does not provide an easily supervised solution for the delivery of a learning objective.

After considering the reflection of the 8 ideas for EER puzzles, the following three ideas have shown the most potential as the basic construct of an EER puzzle.

4.4 Three Final Ideas

These three selected puzzle ideas from the ideation phase are presented to the client team and supervisors. They are very basic concepts and do not contain all the desired requirements.

The three ideas will be presented in sequence and receive feedback from the people mentioned above. NOTE: At the time of developing these ideas, the puzzle spot was placed for the beginning of the EER. Later the client changed it to the middle. This has an impact on the difficulty of the puzzle, which should become exponentially more difficult over the course of an ER.

4.4.1 Top Idea 1

The first of the three selected ideas is idea 3. Figure 14 shows the rough structure of the puzzle. The theme of green energy is integrated in the form of the solar cell that has to be illuminated by the players. The sequence of the puzzle can be seen in point 4.2.1.3 Order of events.
The puzzle includes the following requirements:

- **Topic:** The puzzle fits the overarching theme of the climate crisis.
- **Technology:** The puzzle contains the desired technology, which is prescribed by the graduation project.
- **Look:** The puzzle will have a futuristic decoration that resembles a very technical device with metal optics.
- **Learning objective**: The learning objective is creating awareness about solar energy.
- **Difficulty:** The puzzle is very easy because it is intended for the beginning of the EER. It offers an easy introduction to the technology used and the topic.
- **Robustness:** When completing the prototype, care is taken to ensure that everything is installed securely. The handling is tested through user tests to see whether problematic areas still exist.

- **Reset:** The puzzle will be very easy to reset by removing the solar cell and, after filling the box, pressing a hidden button to close it.
- **Repair possibilities:** Circuit schematics as well as spare parts and the code will be passed on to the client.
- **Surprise factor:** The puzzle will have two main moments that should create excitement for the player. First of all, the battery is charged with the solar cell and the box is automatically opened by the laser.

4.4.2 Top Idea 2

The second of the three top ideas is idea 4 of the 8 idea variations (see 4.2.1.4). Figure 15 shows a rough representation of the puzzle.
Through teamwork and communication, players must align the mirrors with the connected knobs so that the laser hits the LDR on the box. The theme here is again green energy through the use of a solar cell.
The following requirements are and will be integrated into the puzzle:
The same requirements as in Top idea 1 except for the following ones.
Teamwork: The knobs, which are distributed at different locations in the Airstream, increase the challenge of the puzzle and teamwork. Since the players who give the input cannot see the change in the mirror, it must be communicated.
Difficulty: This game is challenging as it requires coordination and communication from the players.
Reset: The puzzle will be very easy to reset by removing the solar cell and, after filling the box, pressing a hidden button to close it. The knobs must also be turned to a random position.

4.4.3 Top Idea 3

The third of the three top ideas is idea 7 from the 8 idea variations (figure 19). This idea deals with the topic of recycling. Plastic waste distributed in the airstream is used to melt a key to open the box. The following requirements are included in this game:

- **Topic:** The puzzle fits the overarching theme of the climate crisis.
- **Technology:** The puzzle contains the desired technique, which is prescribed by the graduation project.
- **Look:** The puzzle has a futuristic decoration that resembles a very technical device with metal optics.
- **Learning objective**: The learning objective is creating awareness about recycling.
- **Difficulty:** The puzzle is very easy because it is intended for the beginning of the EER. It offers an easy introduction to the technology used and the topic.

- **Robustness:** When completing the prototype, care is taken to ensure that everything is installed securely and securely. The handling is tested through user tests to see whether problematic areas still exist.
- **Reset:** The puzzle will be very easy to reset by removing the plastic trash and, after replacing the key, pressing a hidden button to close it.
- **Repair possibilities:** Circuit schematics as well as spare parts and the code will be passed on to the client.
- **Surprise factor:** The puzzle will have two main moments that should create excitement for the player. First, the activation of the smeltery, followed by the smelting animation and finally the automatic opening of the flap that releases the keys.

4.5 Feedback phase

In this phase, a final idea is presented which includes client feedback. It will also be the final idea that will be worked on in the specialization phases of the design process.
After the feedback session with the client, the laser presented a security vulnerability. The structure of the escape room has also changed. The customer has now introduced three acts into the EER, understanding, courage and love. In order to take the new circumstances into account, an idea inspired by Ideas 1 & 2 was developed.
Care was taken to ensure that there was no safety risk from the laser, that the puzzle fit into the “Courage” act and that it embodied the climate theme more.

Changes

The laser is replaced with a powerful flashlight that poses no safety risk to the player and represents the sun. The flashlight will produce yellow light and shine on a solar cell. This prevents the safety risk of the laser and provides a more true integration for the solar cell.

In order to better address the topic of the climate crisis, only objects that have a connection to the topic will be used. Instead of the three mirrors from idea 4, three objects are used, each representing energy producers/users that have a bad impact on the environment. The first item is a power plant, the second item is an oil pump and the third item is a sports car that runs on fossil fuel. The function of these objects is to contrast with green energy producers, such as solar energy. Players have to interact with the objects to solve the puzzle.

4.6 Final Idea description

The basic theme of the game is renewable energy. Through a contrasting presentation between nuclear energy, oil, gasoline, and solar energy, a learning effect is to be achieved that gives the user a negative association with energy generation methods that have negative effects on the environment.

The system setup is shown in Figure 20. A light source that is supposed to represent a sun, a house with a solar cell on it and three objects that stand between the sun and the house can be seen. The three objects represent the energy methods that have a negative impact on the environment. The first item is a miniature nuclear power plant. The second item is an oil pump. The third object is a car that runs on fossil fuel. Smoke comes out of each of the three objects, which prevents the light from the flashlight (sun) from falling on the solar cell on the house.

The basic goal is to remove the three objects to clear the path for the beam of light.

The blocking objects are locked at the beginning of the game and cannot be removed. They are unlocked through interaction by the player. Forms of interaction for unlocking the objects could be quiz questions or physical interaction with the system in the form of minigames.

The puzzle is successfully completed when the light hits the solar cell and the door to the house can be opened. Behind the door there will be an item or code that is needed for the following puzzle.

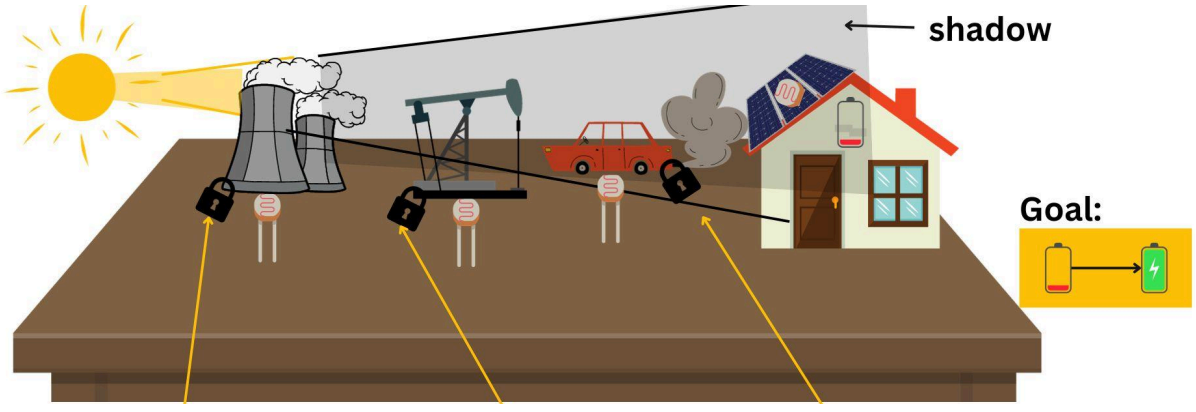


Figure 20 - Planned puzzle set up

Instead of the players moving the mirrors, they move the polluting objects like power plants or fossil fuel cars out of the sun to enable the generation of energy.

After the feedback stage, a mixture of idea 1 and the safe variant of idea 2 emerged as the most promising. This puzzle design not only offers space for interaction with the player and the game but also a clear learning objective. Further refinement of the idea will be presented in the next chapter.

Chapter 5 - Specification

This chapter provides a detailed look at the system behind the chosen idea for the EER piece. The game is designed to be fun and also to convey a learning objective. It relates strongly to the topic of the climate crisis by presenting different ways to generate energy. The goal of the learning objective is to recognize green energy as the solution to climate change.

5.1 Airstream specification

The Airstream is the EER venue. It is an old American caravan which has been renovated and converted by the Escapeclimatecrisis.de team since spring 2023. It has an interior length of 6.8 meters and a width of 2.5 meters. The area circled in red in Figure 21 shows the area planned for the puzzle. There is now, not a fold-out lounge as in the drawing, but a round table with chairs. The width of the table offers a well-suited surface for the linear design of the puzzle.

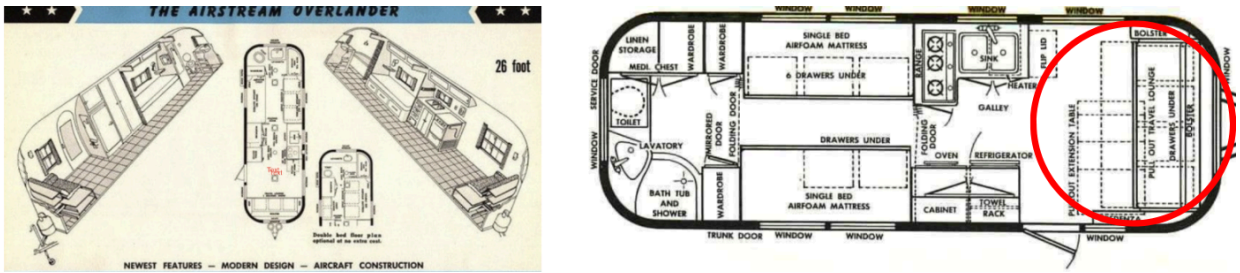


Figure 21 - Airstream blueprint

5.2 Prototypes

The first prototype that is used for an initial evaluation is presented below.

5.2.1 Prototype 1

In order to test the basic function idea of the puzzle, a cardboard prototype was created (figure 22). This contains a flashlight that can be brought to the desired height using a tripod, a house made of cardboard that does not yet have a door and triangles. For the three objects, simple cardboard triangles were used to block the light. LDR sensors were mounted on a plate at equal intervals, which detect whether the respective cardboard triangles have been removed or not. When all LDRs receive light, a green LED on the house turns on. Small pieces of paper, with locks printed on them, were placed on the plate to symbolize that the triangles cannot simply be pulled out. In addition, three questions A, B & C were placed next to the prototype. If questions A-C were answered correctly, the researcher removed the piece of paper that represents the lock to allow the playtesters to remove the triangles.

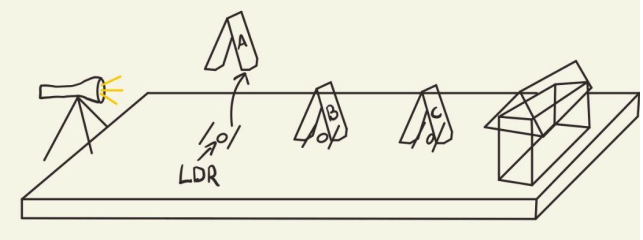


Figure 22 - Visualization paper prototype

The use of the prototype was, on the one hand, to test the functionality of the LDRs and, on the other hand, to test the understanding of the problem of removing objects that get in the way.

5.2.1.1 Usertest Prototype 1

A user test was carried out with two testers from the researcher's known circle.
The process was as follows. At the beginning, the testers were given time to look at the system. If the answer to the quiz question was correct, the paper with the lock was removed from the plate. The game was successfully completed when all three triangles were removed and the LED lights up.

5.2.1.2 Result for Prototype 1

The LDR sensors successfully detected the removal of the triangles and turned on the LED as soon as the light from the flashlight hit the surface of the LDR.
The connection between answering the questions and being allowed to take away a triangle was recognized. The task of removing the triangles in order to no longer interrupt the light beam was also recognized.

The results of the first user test were presented to the client and the supervisors. The client's request from the feedback session was to change the unlock mechanism since "asking questions" is not a suitable method to be playful and joyful and another interaction should be found to remove the triangles.

5.2.1.3 Revision of the unlocking methods for the objects

The message of the game is to remove the “bad” energy producers/users. To symbolically tie in with this, physically “switching off” was chosen as the action to unlock the items. By switching off the respective methods, you can prevent the negative impact on the environment. Therefore, actions to switch off the objects (Power Plant, Oil Pump and Car) were developed.

For the power plant, a high-current lever was chosen as a symbol for switching off. The player must pull down the lever located in the fuse box to unlock the power plant.

To turn off the oil pump the player has to hack it. The oil pump system is also in the fuse box and will consist of an LCD screen and a USB slot. The player must find the USB stick hacking device developed by Dorothy Hartman in the Airstream and install the “Green Virus” using the USB interface to the pump system.

The car is conventionally switched off with a key. To do this, a car lock will be attached next to the object on the base plate of the puzzle and the object will be unlocked by inserting a car key and turning it to the left.

5.2.2 Prototype 2

A prototype was created to test the new unlock methods.

5.2.2.1 System structure

In order to simplify the structure of the system, it is divided into four parts. 1. Base plate, 2. Power plant, 3. Oil pump, 4. Car

5.2.2.2 Base plate

The base plate of the system consists of a lock mechanism and LEDs for visual feedback. An approx. 40 cm long rectangle with a height of 4 cm was made using cardboard in which the components were installed.

Figure 23 - Miniature house

The house was already used in Prototype 1 and is made of cardboard. A solar cell was painted on it.

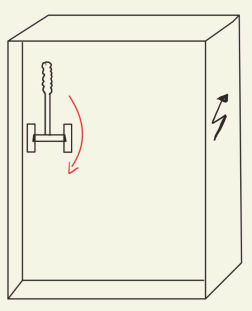
5.2.2.3 Power plant

Figure 24 - Miniature power plants

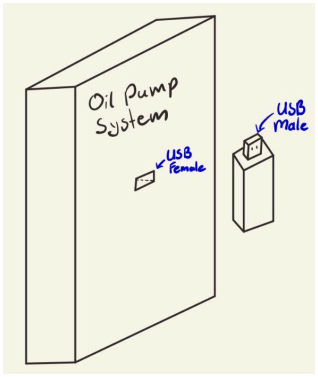
This object is the paper prototype of the power plant.

Figure 25 - Lever prototype

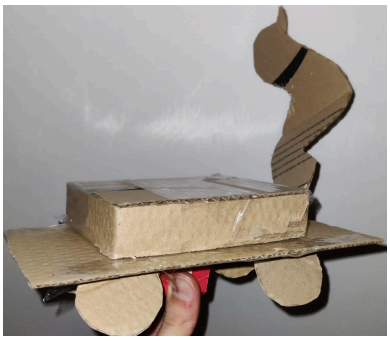
The high currency lever to switch off the power plans.

	Figure 26 - Fuse box and lever

5.2.2.5 Oil pump

	Figure 27 - Miniature oil pump A miniature oil pump was created out of cardboard.
	Figure 28 - Oil pump computer and hacking device

5.2.2.6 Car

	Figure 29 - Miniature car A cardboard car was created which has a keyhole on one side.

The task of this prototype was, on the one hand, to create a visualization of the final idea for presentation to the client and supervisor, and on the other hand to carry out a playtest with the Wizard of Oz mechanics.
The Wizard of Oz method is used in prototype testing and is characterized by the researcher controlling the prototype instead of the intended technology in the final product. It has the advantage that the technology does not have to work yet and that if the technology no longer needs to be used due to the test results, resources are saved [51].

The game test was carried out with people from the local social environment. The aim of the test was to test the logical progression of the game, the understanding of the interaction of the components and the understanding of the topic.

Two people took part in this playtest. How the players interact with the prototype was observed.

The result of the small playtest was that the theme was recognized by both players, the connection between the unlocking mechanism and the components of the game was recognized and both players completed the puzzle. It was clear that the players seemed more excited to interact with the objects than with the paper prototype. The joy of solving part of a puzzle also seemed greater than answering a quiz question like in the paper prototypes.

5.3 Requirement specification for the final prototype

To create the final prototype, the following requirement specifications were created based on the feedback from the client, the supervisors and the results of the first user test. These describe what effect they have on the final prototype of the EER puzzle.

5.3.1 Content Requirements

5.3.1.1 Topic

The puzzle works as a reflection of the current electricity generation situation in the world. The players should get the feeling that they have a device in front of them with which they can influence the world. This is achieved through decoration of the prototype, which is common for solarpunk.

5.3.1.2 Story

In order to integrate the puzzle into the story, the player is told through the story that the final puzzle is a highly sophisticated device developed by Dr. Dorothy Hartman with whom you can observe and change the current energy production situation in Germany. The player should get the feeling of having control over the change with the help of the device and that the effects can be seen directly.

5.3.1.3 Theme

The final puzzle will be given a futuristic look through decorations to represent a highly technical device from the future with which you can see the current energy supply situation in Germany.

5.3.1.4 Communication of a learning objective

By switching off mechanisms of the respective energy production methods with a negative impact on the environment, the learning objective is presented to the players. The players should recognize that the negative production methods literally "stand in the way" of the green energy methods with positive effects on the environment.

5.3.2 Game characteristics requirements

5.3.2.1 Adaptation to the target group

The game is designed in such a way that no previous knowledge is required to solve it and every player in the target group can solve it.

5.3.2.2 Appropriate difficulty level

The prototype should achieve a desired difficulty of 7 on a scale of 1-10. The difficulty of the puzzle is made up of search games and combination games and can

therefore be influenced by changing the hiding places of the objects (key and hacking device). For this purpose, tests are carried out in the evaluation phase and adjustments are made if it has not been achieved.

5.3.2.3 Enjoyment

The game is structured in such a way that a chain of puzzles is created. This structure gives players a sense of partial success after each partial puzzle. This increases the fun factor and prevents boredom.

5.3.2.4 Teamwork

In order to promote teamwork in the game, there is a clear distribution of tasks in the game. Some players have to look for the items they need, other players have to examine the puzzle to find the right interfaces (USB slot & car lock) and others have to take them out when unlocking the items. Between all these steps, there must be strong communication about what is being sought, what has been found and what needs to be done.

5.3.2.5 Interesting design

In order to create surprising moments, audio, visual and physical output will be used. Visual signals are generated by numerous LEDs and LCD displays. Beepers and mechanical sounds provide audio feedback if something happens. The final automatic opening of the house door offers a surprising moment with the help of the physical output.

5.3.3 Technical requirements

5.3.3.1 Robustness

When choosing materials for manufacturing, two sturdy wooden box constructions will provide the basis for the hardware. The house that is on the base plate is also made from 6mm thick wooden panels.

The locking mechanism that holds items on the base plate provides the largest attack surface for problems. Therefore, skin-tight 3D mounts were printed for the servo motors to anchor them firmly. The hooks that are on the servo motors are glued to the attachment on the servos with the help of strong plastic glue. In order to also strengthen the objects, the ring screw that is held by the pick was not simply drilled into the clay, but was reinforced with a piece of wood during shaping and embedded in the clay. For visualization please refer to figure 34&35 in chapter 6.

5.3.3.2 Easy Repairability

The prototype is designed so that the hardware can be easily accessed if necessary. To repair the door opening mechanism, you can remove part of the roof behind the house. To access the locking mechanism of the objects, you can remove the bottom of the baseplate. To access the hard bar of the oil pump system or the power plat lever, you can remove the second wall in the fuse box. In addition, an external document with instructions for resetting the game as well as the game itself and circuits is passed on to the client.

5.3.3.3 Quick reset time

To enable a quick reset of the games, the following steps have been used. The car lock closes the servo when the keys have been turned back to the starting position. The key can then simply be removed and hidden again. The same applies to the lever of the power plant puzzle. As soon as the lever is back in the starting position, the servo closes. For the oil pump hacking puzzle, a small hole was drilled into the bottom of the fusebox. Behind this hole there is a push button that triggers the reset function in the code. A thin pin must be pushed through the hole to trigger the button. The small hole prevents players from accidentally pressing the button and resetting the puzzle.

5.3.3.4 Multisensory appeal

In order to do justice to the chapter "MUT" in which this puzzle appears, audio alarm signals are used to show the player that an illegal activity is being carried out. The player then has to show courage to solve the puzzle despite the deterrent signals.

5.3.3.5 Appropriate integration

In order not to make the table on which the baseplate stands unusable, the baseplate is mounted as far back as possible. This allows more than 75% of the table to be used for other purposes. The fuse box is mounted on a free wall and therefore does not pose a size problem.

5.4 Integration in Act 2 Courage

In order to integrate the puzzle into the second act, the part puzzle is included. Alarm system integrated. These are intended to use audio and visual feedback with beeping and blinking to symbolize to the player that an illegal action is being carried out. The player then has to muster the courage to carry out the action despite the alarm. It is not intended to represent that a change in energy production policy can only be achieved through illegal means, but rather to show that change is possible with courage.

Chapter 6 - Realization / Implementation

This chapter presents the final design specifications, the system setup of each technical part of the final puzzle and the composition of the puzzle.

6.1 Hardware

Due to the interchangeability of the individual mini games, the puzzle was divided into 4 separate systems. These systems are decomposed and explained below in figure 30.

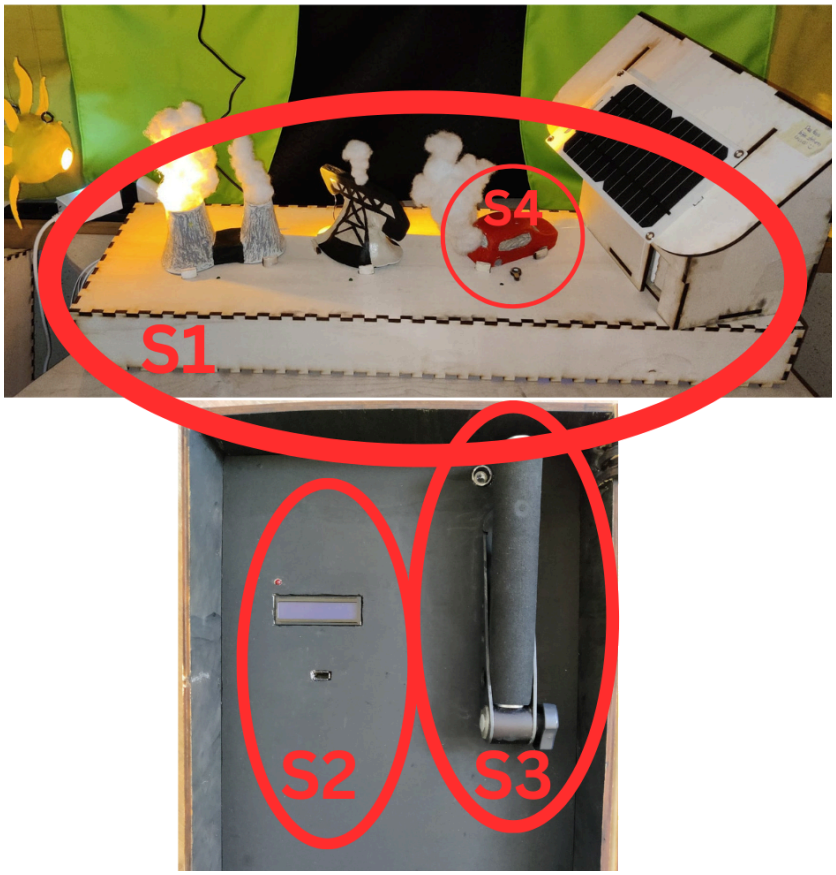


Figure 30 - Overview of the system layout

Based on the separation in figure 30, the parts below are labeled S1-4.

6.1.1 S1 Base plate

6.1.1.1 Use in the puzzle

The base plate forms the basis for the game. It is located on the table in the right area of the Airstream. The job of the base plate is to provide a housing for the lock mechanisms of the three objects. It can also detect how many objects are on it at any time in the game. And finally, once

all the objects have been lifted, it can open the door of the house on it to show the goal (code for the next puzzle). On the left side of the base plate (figure 30 & 49) the flashlight that acts as a light source to trigger LDRs can be seen. It is a USB C rechargeable flashlight that emits sun-like light with a yellow film. For the sun, a sun-shaped covering was placed around the flashlight using clay.

6.1.1.2 System base plate

The technical specifications and their function of the base plate are presented below and the system schematics are shown in detail in figure 31.

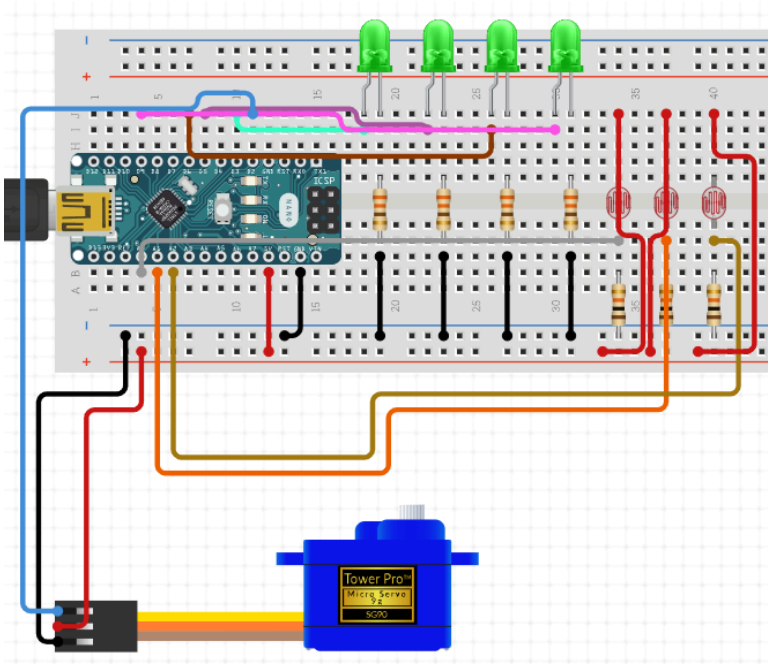


Figure 31 - System schematics base plate

The baseplate housing consists of a laser-cut wooden box with 6mm thick wood. This wood thickness is sufficient for the objects weighing a total of approximately 2 kg that are placed on it. Even if players handle the construction roughly and try to push it in, nothing happens due to the thickness of the wood.

The basis for the technical microcomputer control is an Arduino Nano. This is an inexpensive but powerful microcontroller that controls the following components.

One LDR per object is used for object detection on the base plate. An LDR is a resistor that gives a value from 0-1024 based on the incidence of light. This value is used to detect whether an object is on the base plate. This is done by mounting the LDR on the ceiling of the base plate box directly below the area where the objects will stand. By placing an object on it,

less light falls on the LDR and an object can be detected. Figure 32 shows the inside of the housing in detail.

Green LEDs are used to send visual feedback to the player. These are placed next to the area where the objects are located. Each LED lights up as soon as the corresponding object has been successfully removed and symbolizes the player solving a part puzzle. The placement of the LEDs can be seen in figure 45.

This creates three pairs, each with one LDR and one LED for each of the three objects.

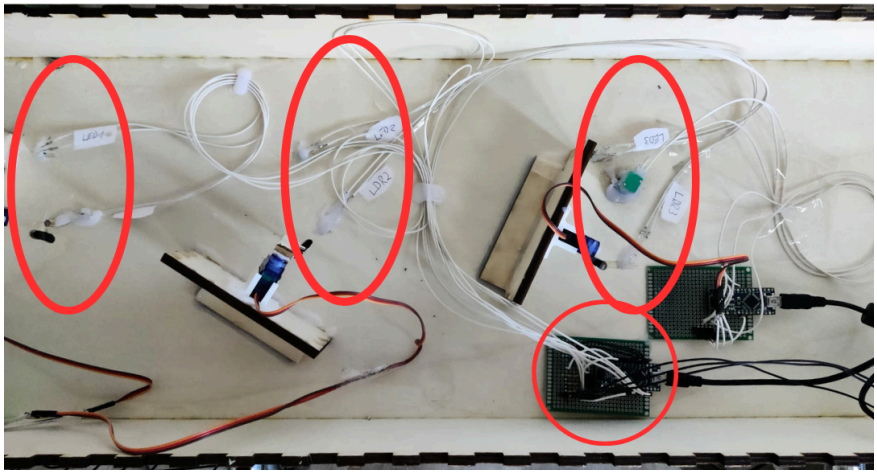


Figure 32 - Implemented setup (inside the base plate box)

The finale of the puzzle is opening the door of the house which is on the right side of the base plate. Integrated into the house is a servo motor that opens a small wooden door with a movement of 120 degrees. Figure 33 shows the door mechanism in detail. The opening of the door is triggered by all three LDRs receiving light of the flashlight (sun). There is a slightly flexible wire attached to the arm of the servo motor, which is connected to the door. The door can be opened using a hinge on the inside of the house wall, but cannot be pushed open by players. A green LED mounted on the door provides visual feedback to indicate the opening of the door if it remained undetected by the players.

A list of the exact components can be found in Appendix 9.

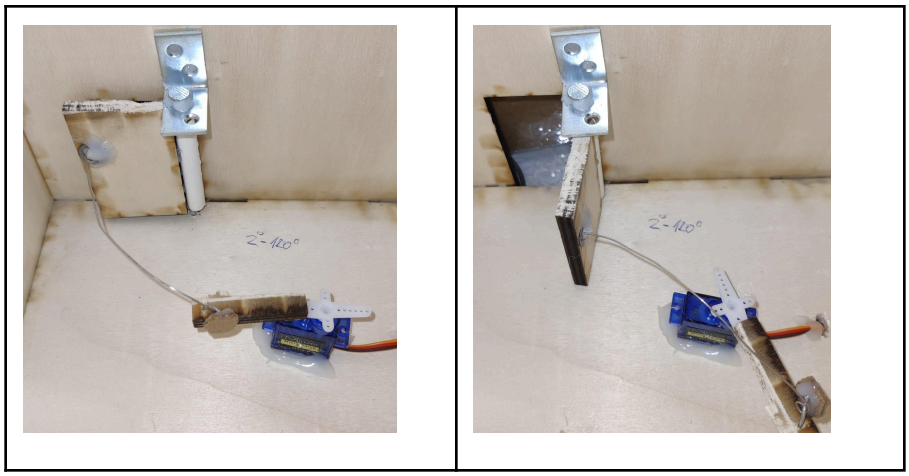


Figure 33 - Door opening and closing mechanism

6.1.1.3 Locking mechanism

To ensure that the objects cannot be removed before solving the puzzle part, the following locking mechanism was designed. The mechanism includes two parts. On the one hand the item that needs to be locked and on the other hand the hook on the base plate.

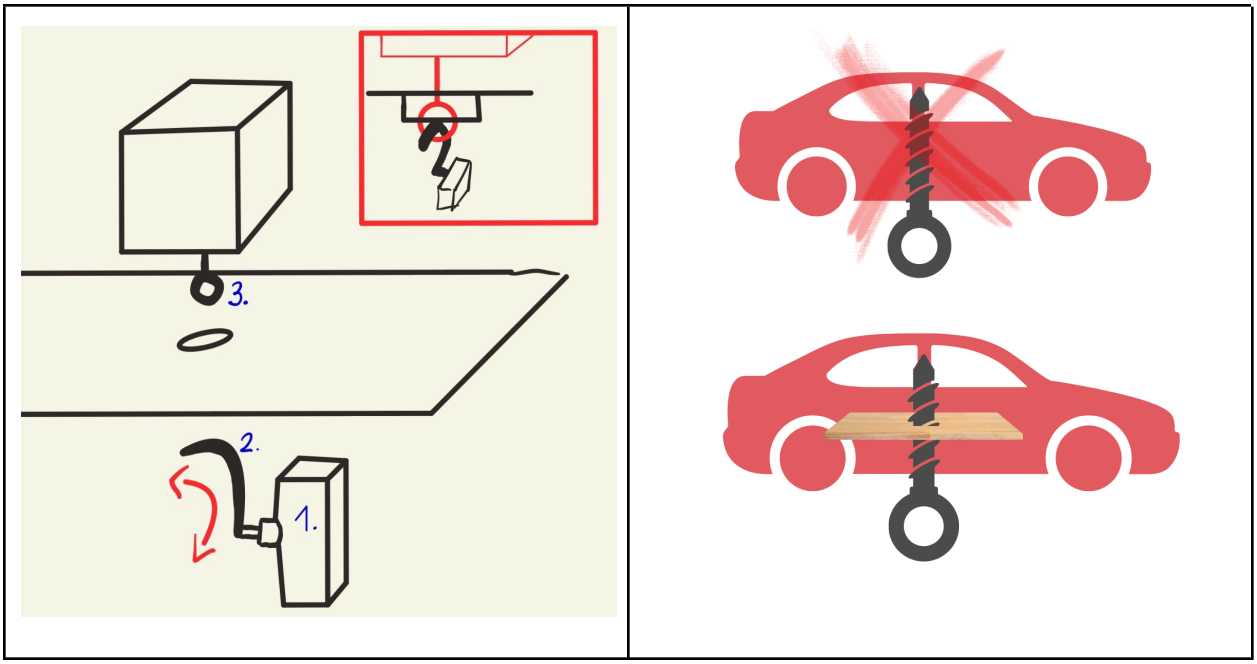


Figure 34 - Locking mechanism & Figure 35 - Object counter part

The object is inserted from above through a slot with the perfect size of the ring screw. Due to the thickness of the wood of 6 mm, the ring screw (number 3, Figure 34) protrudes perfectly from the bottom so that only the diameter of the hook (number 2, Figure 34) fits through. This prevents wobbling and the object literally sticks to the base plate. As can be seen in figure 35, the ring screw was not simply screwed in the object, but worked into the clay with a piece of

wood that extends the surface. To release the objects, the servo (number 1, Figure 34) moves backwards 12 degrees and the hook is removed. This locking method is used for all three items. Research into further mechanisms was carried out in advance. An electromagnet that switches off the attraction to unlock objects was unsuitable due to cost reasons and because of doubts about the carrying capacity in combination with players human strength. The selected locking mechanism was tested using a prototype. This was presented to and got tested by the supervisors, who approved the usage.

6.1.2 S2 Oil Pump system

6.1.2.1 Use in the puzzle

The oil pump system is the first of the three puzzle parts of the puzzle. Solving this puzzle unlocks the oil pump on the base plate. By inserting the “Green virus” (USB stick) into the oil pump system placed in the fuse box, a hacking animation is carried out. The system uses a blue LED and an LDR to detect whether the USB stick has been inserted by interrupting the light of the LED on the LDR.

6.1.2.2 Puzzle objects

- **Hacking device:** The hacking device consists of a USB stick which was formed into the shape of a leaf using clay (figure 36). It is called the "Green virus" and can shut down oil pumps. The device will be painted green in the final product.

Figure 36 - Hacking device “Green virus”

- **Miniature oil pump:** The miniature oil pump (figure 38), which is inspired by a typical American oil pump (figure 37), was also made of clay. The advantage of the clay is that the object ultimately has a manageable weight. As already mentioned, the ring screw with the reinforcement piece of wood is embedded here.

Figure 37 - Typical American oil pump & Figure 38 - Oil pump of the puzzle

6.1.2.3 System Oil pump

The oil pump puzzle is located in the fuse box, which was made from a wooden box with a double wall. The box has the same material as the base plate box and is equally resistant to external influences. The job of the fuse box is to contain the technical components of the oil pump and the power plant puzzle and to give the player the feeling of managing a device that would normally require specialist personnel. The technical components of the oil pump puzzle are as follows.

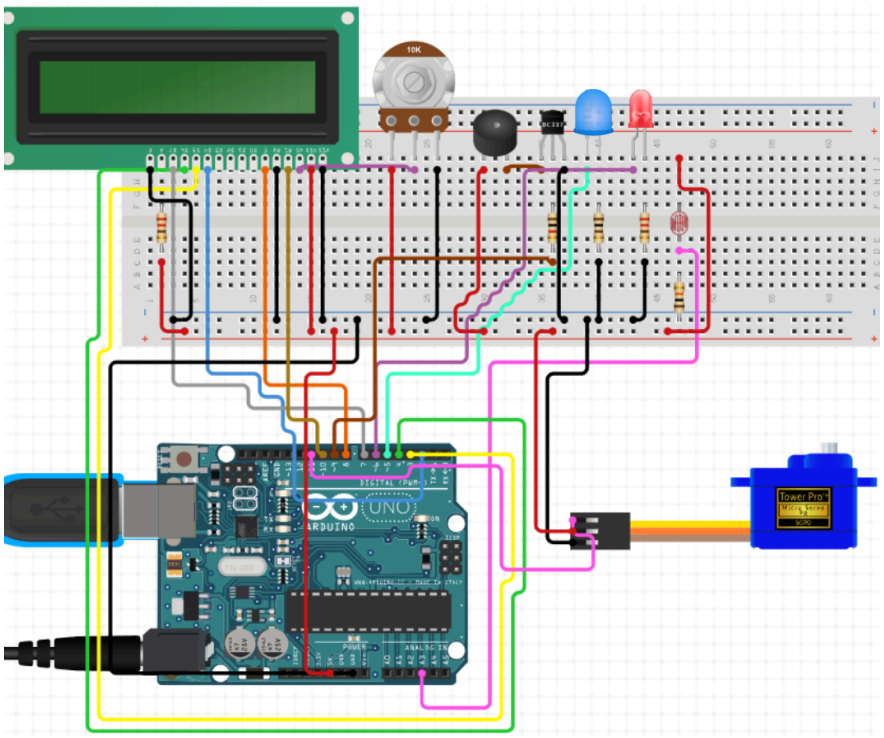


Figure 39 - System schematics oil pump system

The basis of this puzzle is an Arduino Uno microcomputer. It is a bit more expensive than the Arduino Nano used for the base plate, but has more digital pins which are needed for this puzzle.

A 16x2 LCD display provides visual feedback about the hacking process (figure 40) and the puzzle. It is a liquid crystal display that can show a total of 32 characters split in two rows.

A red LED provides visual feedback for the alarm imitation by blinking in a high frequency.

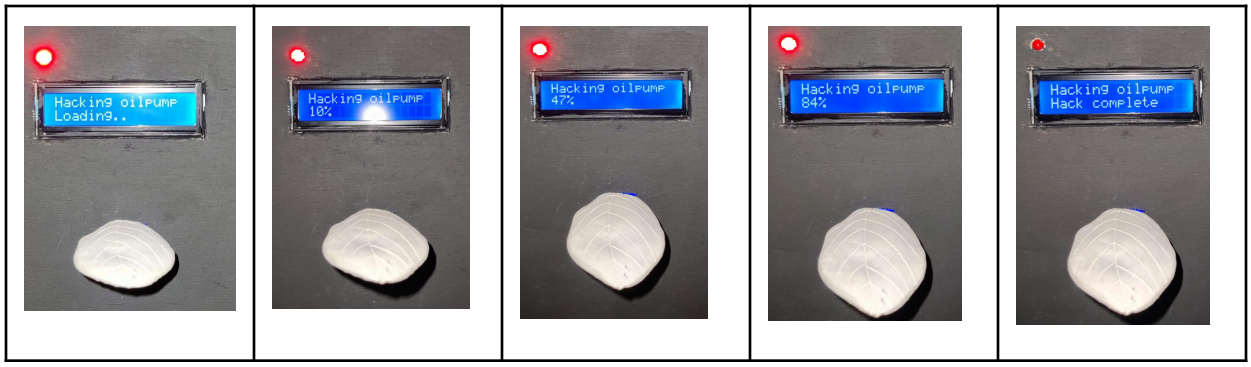


Figure 40 - Hacking animation

In addition to the visual feedback, a piezo beeper is used to imitate alarm sound with the red LED.

To trigger the hacking animation on the LCD display, the following mechanism was designed. For detection a light source and a sensor are needed, in this case a blue LED, and an LDR sensor. These were each mounted on a female USB slot housing at the top and bottom. Previously, holes with the correct size for the LED and LDR were drilled into the metal. Now the LED can shine through the USB slot on the LDR. When the male USB stick (hacking device) is inserted, the light beam is interrupted, the LDR detects darkness and the animation is played. Figure 41 shows the structure in detail.

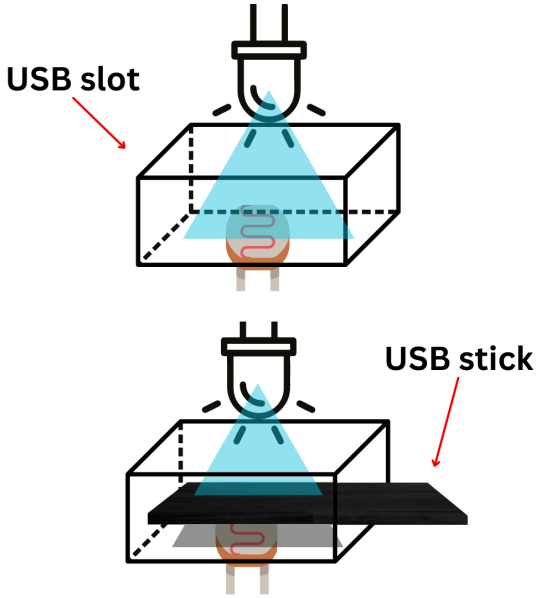


Figure 41 - Detection of USB hacking device

The servo motor is connected by an extended cable between the fuse box and the base plate and is responsible for unlocking the item once the hacking process has been completed. The assembled servo motors can be seen in figure 32.

6.1.3 S3 Power plant system

6.1.3.1 Use in the puzzle

The power plant puzzle is the second of the three part puzzles. It unlocks the miniature power plant on the base plate. It is also located in the fuse box next to the oil pump system. Here, the player has to pull the high cuttency lever to unlock the object.

6.1.3.2 Puzzle object

Figure 42 shows the miniature power plant. It is made of clay and has a piece of wood for reinforcement and to create a stable connection between the small and the large tower. The smoke consists of cotton balls glued together.

Figure 42 - Power plant object of the puzzle

6.1.3.3 System Power plant

The power plant puzzle is also located in the fuse box. The technical components are the following.

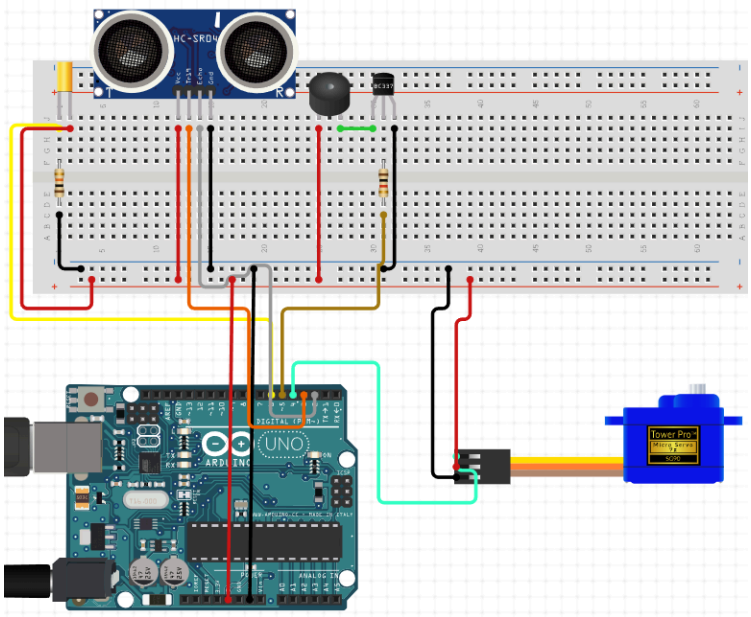


Figure 43 - System schematics Power plant

The basis of the puzzle is an Arduino Uno microcomputer (figure 43) which, together with the oil pump system, is located behind a second wall of the fuse box.

The location of the lever is detected by a tilt sensor in the lever rod. This can detect whether the lever is pointing up or down. The start position is pointing up and the end position is pointing down.

Triggered by the detection of the tilt sensor, the servo is connected to the base plate through an extension of the cable. It is responsible for unlocking the object.

An ultrasonic sensor and a piezo beeper are used to give the player audio feedback. An Ultrasonic sensor can detect distances of up to 4 meters. It is responsible for detecting whether a player is approaching the lever. Based on this input, an alarm signal is played by a piezo beeper. This is intended to scare the player and encourage the player to be brave. The ultrasonic sensor is embedded in the second wall right next to the lever handle. Figure 44 shows the location of the lever and the ultrasonic sensor.

Figure 44 - Location lever and ultrasonic sensor

6.1.4 S4 Car system

6.1.4.1 Use in the puzzle

The car puzzle is the last of the three part puzzles. It is also in the base plate box. The player has to find the key in the room and combine it with the car lock which is located right next to the miniature car on the base plate.

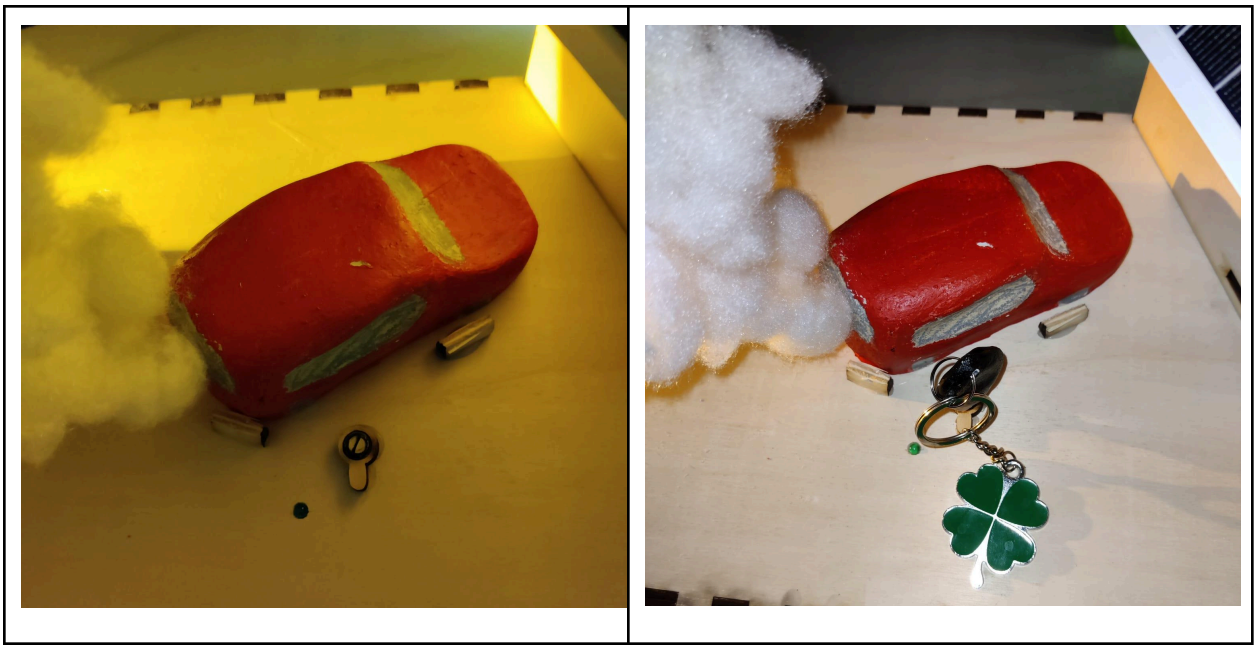


Figure 45 - Car, keyhole and key

6.1.4.2 Puzzle objects

Figure 45 shows the miniature sports car which was also made from clay. Also visible in the figure is the car key, which consists of a long piece of metal for the key bar and clay for the handpiece.

6.1.4.3 System Sportscar

The car puzzle system is located in the housing of the base plate. The technical components are the following.

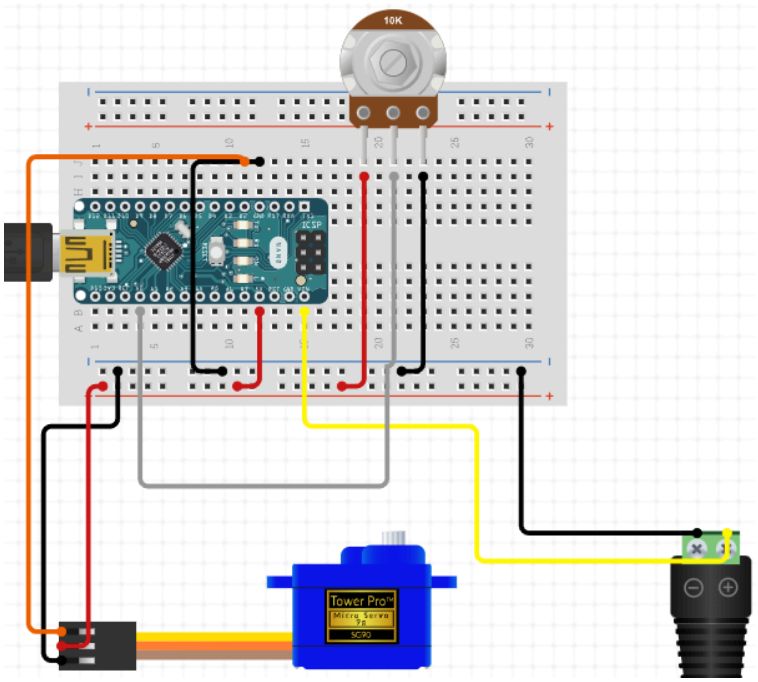


Figure 46 - System schematics Car

The basis of the puzzle is an Arduino nano microcomputer. This controls a servo motor that is responsible for unlocking the sports car. The input for carrying out the unlocking is a potentiometer. A potentiometer is a rotary switch that displays an analog value from 0 to 1024. It acts as a detector for the rotation of the key. As can be seen in Figure 47, there is a gap on the knob into which the key is inserted. To make it easier to insert the key, a small tube was glued around the knob. When the key is turned to the left the Nano receives the analog value ~ 10 and the servo unlocks the car from the base plate.

Figure 47 - Key detection (potentiometer)

6.2 Final sequence of the puzzle

This flow diagram (figure 48) was created to show the exact process of the puzzle. It serves for the reader's understanding and as a guide for the gamemaster to understand the players' steps.

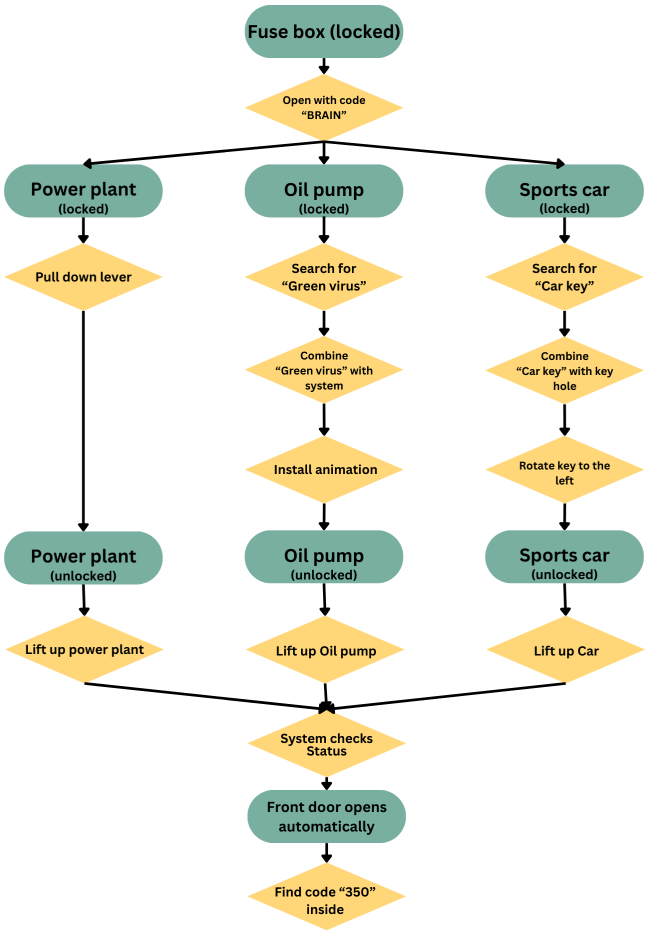


Figure 48 - Flow diagram of the puzzle

6.3 Possible clues

As stated in the interview with the gamemaster, it takes a certain feeling to give the right hints at the right time. Since there is no permanent gamemaster in the project team and there are changes from time to time, the following list of tips is intended to help provide the right clues.

If the connection between base plate and fuse box is not recognized: "Opens the fuse box."
When the sun doesn't shine: "Shouldn't the sun shine?"
If the car key isn't found: "How do you normally turn off a car?" "Where do you store your keys when you're out and about?"

If the hacking device is not found: "Search the room for technical objects." "You have to hack the oil pump!"
If the players don't lift the objects: "Try lifting the objects." "Remove the polluting objects!"
If they do not look through the door: "Who's looking through the door?"

Chapter 7 - Evaluation

This chapter will present the approach and results of the user evaluation and the play test of the final prototype. The goal of this evaluation was to find out if the set requirements have been reached. Additionally, the goal was to gather user feedback on the handling and usability of the prototype in order to identify possible improvements.

7.1 Approach

For the evaluation a playtest with observations followed by a survey has been carried out.
The questions of the survey were focused on the topic of the game, the playtime, the theme, the difficulty, entertainment value, encountered difficulties while playing, motivation for the workshop and improvements for the game.

The survey consists of three parts, namely:

1. **Content questions**
   These questions were aimed at the content of the game. These questions were formulated so that they could be answered with keywords or short sentences. The aim of this question section is to find out whether the content requirements have been met.
2. **Game questions**
   These questions were related to the characteristics of the game. Most questions are in the 5 point Likert scale format in order to graphically compare the results of the participants. The aim of these questions is to test whether the game characteristics requirements have been met.
3. **Technical requirements**
   The third part of the questions focused on the technical function of the game. Here the participants were given space to give qualitative feedback on the function and implementation with open questions.

The observations and survey took place on UT campus in the airstream (EER environment) using the final prototype of the puzzle. Playtesters were invited to participate to test each of the three puzzles one by one and fill out the survey afterwards.

A copy of the survey can be found in Appendix 5. The survey and observation were approved beforehand by the ethics committee of the EEMCS faculty of the University of Twente. During the playtests no audio or visuals were recorded. The survey answers were anonymised. The completion time of each group has been noted down. Since the final puzzle will be played in a series of puzzles a starting keyword to open the fuse box has been given to the players at the beginning of each test which they would normally have received from a previous puzzle.

Playtester:
In total 12 playtesters participated in the survey. They played in groups of 2-3 people. The testers matched the required age group of 16+. It is important to note that the majority of playtesters were students with a technical background and mainly from the social environment of the researchers.

7.2 Playtest Setup

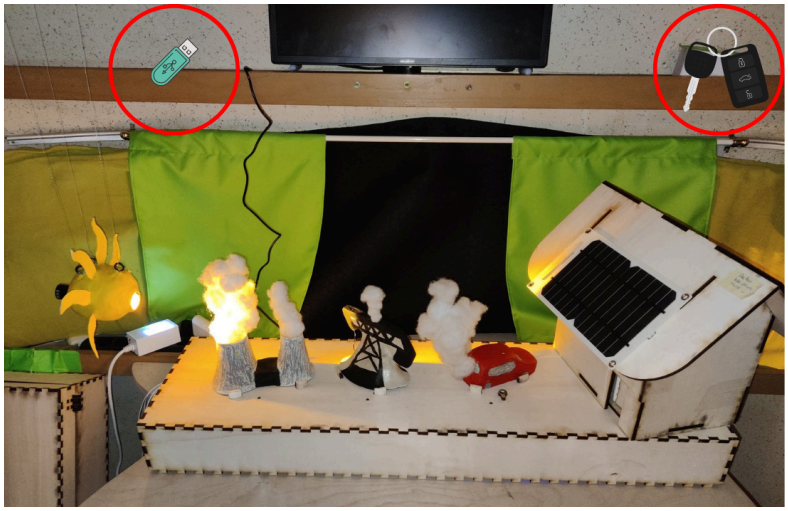


Figure 49 - System setup playtest

Figure 49 shows the system setup for the playtest. The two red circles show the places where the objects for solving the oil pump puzzles and car puzzles were hidden. In the lower left corner of the figure you can see the location of the fuse box.

At the beginning of the playtest, the information brochure (Appendix 3) was read to the participants and they were given the opportunity to ask questions. This was followed by signing the consent form for participation. The participants were intentionally not briefed on the topic of the EER or the puzzle in order to find out whether it was recognizable through playing. Since the playtest was only planned for the three games developed by Arthur .L.Torre, Hilke van den Born and Mark Ziegelhöfer, the participants did not test any other EER games present in the Airstream. In order to be able to draw more precise conclusions, the groups played the games individually and not as a puzzle chain of three games.

At the same time as the timer was started, the players were given the code word, which is necessary for the start of the game. "BRAIN" is the word that opens the word lock to the fuse box.

7.3 Results

7.3.1 Content requirements results

The first two questions of the questionnaire related to the requirements described in section 5.3.1.1 Topic. Here the participants were asked what theme they associated with the escape room and what climate topic the game was about.

The results of the survey were clear. 100% of the participants recognised the topic of the EER (“climate crisis”, “climate change”). 10 of 12 participants recognised the topic of the puzzle (“Green energy”, “energy sustainability”). The other 2 participants did not miss the topic but rather misunderstood the question and made a more general problem statement. (“Pollution is blocking our ability to absorb sunlight”).

The results show clearly that the topic of the EER and the puzzle are recognisable and match the intended topics of climate crisis and green energy.

7.3.2 Game characteristics results

The first game characteristic that was asked for in the survey was the **playing time**. The playing time was recorded for each group during the playtest, but was not disclosed to the participants. The timer was started as soon as the teams received the keyword to start and was stopped as

soon as one of the players said the code "350". In the survey, participants were asked to give an assessment of the time required.

The times recorded during the playtest were as follows. The five groups tested each needed 6,7,8,9 and 13 minutes to complete the puzzle. This results in a measured average time of **8.8 minutes** to complete the game.

Number of participants(N = 12)	Estimated time of completion	In percent %
1	4 minutes	8.3%
2	5 minutes	16.6%
1	7 minutes	8.3%
1	8 minutes	8.3%
4	10 minutes	33.3%
3	15 minutes	25%

Figure 50 - Completion time results

The average estimated time of the participants is **9.5 minutes**. Later in the survey, participants are asked about positive aspects of the game. Three participants described the playing time as not too long and suitable.

The next game characteristic tested was the **level of difficulty**. The participants were asked for their assessment on a Likert scale format question from 1-5, where 1 is very easy and 5 is very difficult.

The result was an average difficulty of 3.25.

Converted to a 1-10 scale, this result corresponds to a ~ 6.

Number of participants (N = 12)	Level of difficulty (scale 1-5 were 5 = unsolvable)
1	**2** (**8.3%**)
7	**3** (**58.3%**)
4	**4** (**33.3%**)

Figure 51 - Level of difficulty results

In order to test the **level of enjoyment** while playing, the participants were asked for their assessment on a Likert scale format question from 1-5, where 1 = not enjoyable and 5 = very enjoyable.

Number of participants (N=11)	Value of entertainment (scale 1-5, 5 is highest)
1 (9.1%)	5
9 (81.8%)	4
1 (9.1%)	3

Figure 52 - Level of enjoyment results

The result was that 81.8% of participants rated the level of enjoyment as 4 on a scale of 1-5. ~91% of participants felt overall satisfaction with the enjoyment, only one person rated it as moderately enjoyable.

The next feature of the game tested was **active participation** and the connection between the players' physical input. Participants were asked whether the amount of physical input helped maintain a sense of active participation while playing. This was also a Likert scale format question on a scale of 1-5, where 1 "did not help in feeling active participation" and 5 "strongly helped in feeling active participation".

Number of participants (N=12)	Satisfaction on involvement with the amount of physical input (scale 1-5, 5 is highest)
4 (33.3%)	5
6 (50%)	4
2 (16.7%)	3

Figure 53 - Result effect of active involvement

The results show that 83.3% of participants were satisfied with the amount of physical input and felt involved.

To test the players' **understanding of the connection between the fuse box and the table game**, the participants were asked whether the connection between the base plate and the fuse box was clear. Here a likert scale format question was used with a scale of 1-5, where 1 is "incomprehensible connection" and 5 is "very clear connection".

Number of participants (N=12)	Value of understanding between fuse box and table game (scale 1-5, 5 strong understanding)
3 (25%)	5
4 (33.3%)	4
1 (8.3%)	3
3 (25%)	2
1 (8.3%)	1

Figure 54 - Result Value of understanding

The result is that 58.3% of participants find the connection between the two parts of the game understandable, of which 25% find it very clear. A significant number of participants, 33.3%, found the connection rather unclear.

Another important tested characteristic of the game is the **success rate**. The participants were surveyed using a YES/NO question and the results were compared with the observations. The result shows a success rate of 100%. All groups successfully completed the puzzle.

The last of the tested characteristics of the game is the **motivational ability**. The participants were asked whether they felt motivated to take part in the EER workshop after completing the puzzle. The results show that 91.6% of participants feel motivated to take part in the workshop, of which 58.3% even feel very motivated.

Number of participants (N=12)	Level of motivation after playing the puzzle
1 (8.3%)	5
6 (50%)	4
4 (33.3%)	3
1 (8.3%)	2

Figure 55 - level of motivation after playing

7.3.3 Technical requirements results

Since this project was created in conjunction with the bachelor's degree in creative technology, it was mandatory to implement a technical puzzle idea. From the interviews with escape room visitors of a commercial ER, it became clear that technical solutions have a more unexpected “wow” effect on participants than analog puzzles. To test whether the technology used had any influence on the participants' experience, participants were asked a 3-point Licert scale format question where 1 = technology was disruptive, 2 = technology had a neutral effect and 3 = technology contributed positively .

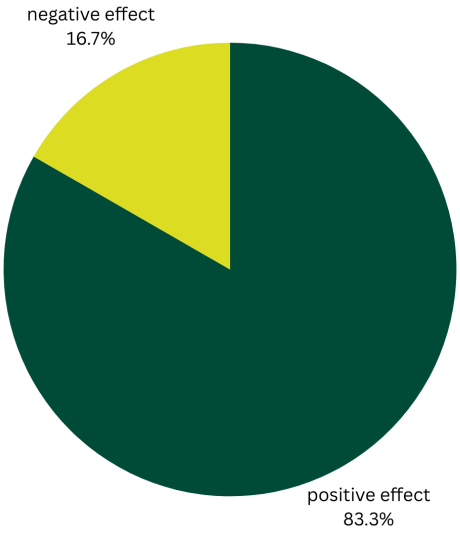


Figure 56 - Result technical influence on experience

The test showed that for a majority of 83.3% the technology used had a positive effect on the experience. Two participants were bothered by the use of technology.

In order to explore the functionality of the prototype, the participants were asked whether they noticed any features that were missing or any problems they encountered while playing. To make it easy to assign feedback to the game component, one question was asked for each of the three part puzzles (power plant, oil pump and car). The mentioned problems / missing features are listed below.

Power plant feedback:

- **Visual feedback**

  It was unclear to players that pulling down the lever already solved the puzzle part because no visual feedback was displayed. This also became clear during the

observation when players pulled the lever down, expecting a reaction and after no reaction was noticed, the lever was pushed back up to turn off the alarm sound.

- **Connection to the lever**
  Since the entire puzzle consists of three part puzzles, a challenge is to connect the puzzle solutions to the objects on the table. Since the lever of the power plant is in the same fuse box as the oil pump system, there was perceived confusion among the participants who first solved the oil pump puzzle. They thought that there was only one solution in the fuse box and desperately searched for the solution for the power plant.

Oil pump:

- **Visual feedback**
  Here too, a few participants commented that they had solved the puzzle but did not know that they could now lift the oil pump. This shows again that there is a lack of visual feedback.
- **Technical problem**
  This feedback about the oil pump puzzle related to a technical problem that was noticed in the first playtest. The sensitivity of the LDR sensor in the code was set too low. This problem was quickly solved on site and no longer caused any problems after it was fixed.

Car:

- **Rotation**
  In the third playtest, a problem was noticed that had previously remained unexplored. The players tried to loosen the objects on the base plate by rotating them. The ring carabiner would have detached itself from the objects and the players would have been able to lift the objects without having to solve the associated puzzle.
- **Robustness**
  The car key broke due to a strong turning in the wrong direction.

A large proportion of the participants were students from the creative technology course, which teaches students to recognize and find creative solutions to problems. Therefore, the survey saw an opportunity to find constructive feedback or improvements to the game. The following is a list of the improvements, which are discussed in more detail in the future work section.

- Car key: By adding incorrect mismatched keys to the keychain, finding the matching key becomes a mini game.
- Feedback: As already mentioned, the topic of visual and audio feedback is also noted here as a successful solution to a part of the puzzle.
- Design: A more beautiful and fitting design of the game was desired, through decoration and colors.
- Sound design: Adding sounds such as car engines or machine sounds brings the puzzle even more to life.

As already mentioned in chapter 4, enjoyment is an important and desired requirement of the client. Therefore, the participants were asked to indicate the most enjoyable elements of the game. By conversely, this can show which elements are not enjoyable and also which type of game elements are well received. The answers of the most enjoyable elements are listed below.

- **LED lights up:** This includes the LEDs on the base plate, which turn on as soon as an object is removed. They represent solving a partial puzzle.
- **Basic design of the objects**
- **Hacking mechanism:** The hacking mechanism was often cited as the most enjoyable solution of the three part puzzles. The reason given was that it felt very real and enhanced the experience.
- **Puzzle chain:** The general structure of the puzzle and especially the puzzle chain of three different puzzle parts were referred to as positive.
- **Door**: The door that automatically opens when all objects are removed.

To find out whether the design process to create a successful game was achieved, participants were asked whether and why they would recommend the game (as part of an escape room) to others.
The result was that 12 out of 12 participants would recommend the game to friends and relatives. They were also asked why they would recommend it. The answers were divided into three categories. 10% of the answers given were classified in the “Interesting” category. 20% of the answers related to the fact that “you can learn something” from it and 70% of the answers related to the entertaining value of the game.

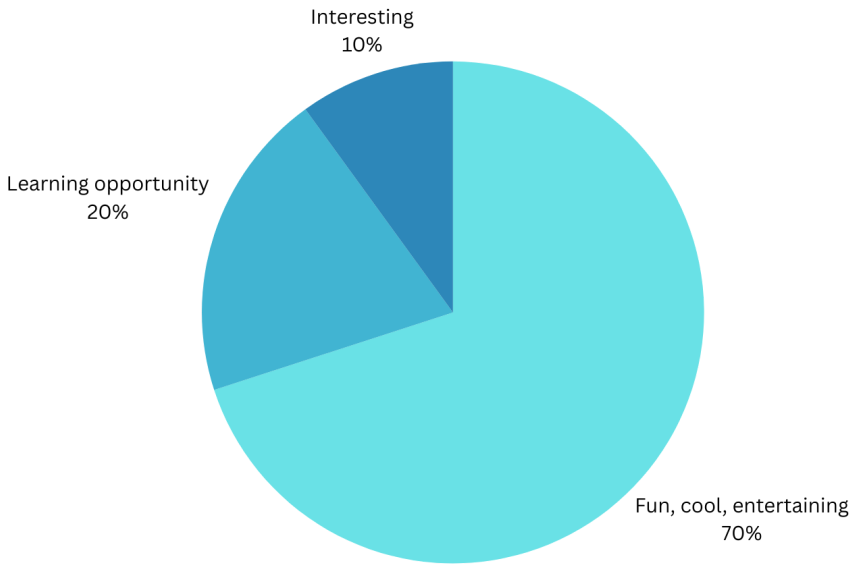


Figure 57 - Reasons for further recommendation

The survey results provided important insight on possible improvements and changes in the game that could enhance the user experience in the future.

Chapter 8 - Discussion

This chapter aims to reflect on the results and limitations of the study, and to propose ideas for future development.

In conclusion, the playtest of the prototype showed that the educational escape room puzzle met the set requirements and received positive feedback from clients and playtesters. Regarding the content requirements, the results show that the topic of the EER and the puzzle are clearly understandable. Because all participants recognized the problem of energy producers having a negative impact on the environment, the first part of the learning objectives, increasing awareness, was achieved.

The results of the game's characteristic requirements were also largely met. These results were particularly important because they accounted for most of the answers to the main research question and represented most of the client's requirements. Due to the total length of the EER, the game time was limited to a maximum length of 15 minutes per game. The result shows an average completion time of approximately 9 minutes. These are well below the limited 15 minutes and contribute to a positive improved flow of the game. This is illustrated by the positive feedback from two participants who found the length to be very suitable. It should be mentioned, however, that the test carried out does not correspond 100% to the final situation in the EERs,

as the two objects, "green virus usb" and "car keys" were not heavily hidden. However, if the hiding places change, there is still room for the maximum completion time. The hiding places not only have an influence on the time required, but also on the difficulty level of the game. Through background research, an ideal value of ~ 7 on a scale of 1-10 has proven to be suitable for an EER puzzle. This is important because if the game is not solved, on the one hand the player is deprived of the chance to achieve the learning objective and on the other hand it would worsen the flow of the game and the experience of the players. The result of the test (difficulty 6) shows that the game is not too difficult and, on the contrary, could be made a little more difficult. A possible way to not only extend the game time but also increase the difficulty would be to choose more difficult hiding places for the objects. The next point that is also related to the difficulty of the puzzle is the connection between the game objects fuse box and base plate. The result of the playtest showed that ~35% of participants found it difficult to recognize the connection. Given this result, the question arises as to whether making the connection clearer influences the game experience of the EER too strongly, since one aspect of an ER is recognizing connections. A 100% success rate, no excess length of the measured times and the observations show that no change is necessary. In order to clarify the question of whether the learning objectives were achieved, the motivational ability of the puzzle was tested. In retrospect, it would have produced a more precise result to conduct a pre & post survey on this question. However, the result shows that the game does not have a negative and rather a positive effect on the willingness to take part at the workshop. In combination with the first part of the learning objective mentioned above, the recognition of the topic, this result shows that the desired learning objective has been achieved. The structure of the EER in connection with a workshop allows the focus of the puzzle to be changed from an educational focus to an enjoyment focus. Therefore, one of the client's goals was to develop a game that was fun to play despite the confrontation with a rather negative topic such as the climate crisis. The results of the test on the level of enjoyment while playing show that this was successful. 91% of participants had fun playing the EER puzzle. This result means that 100% of participants would recommend the game to friends and family. This is particularly important because it helps spread awareness about the topic of the climate crisis.

In order to make a transition to the technical requirements, the result of the satisfaction of the active participation of the players is discussed. The relevant test showed that ~ 80% of participants were satisfied with the amount of physical input required to solve the puzzle. What was noticed during the observation was that the location of the fuse box had a clear impact on the participation of all participants. For the playtest, the fuse box was not hung in the final

position in the airstream, but rather presented on a chair a little closer to the table. This meant that a maximum of 2 people could actively interact with the fuse box. In order to achieve more teamwork and give everyone the chance to give active input, a more open and easily accessible location for the fuse box could be a solution. However, if you consider the circumstances of the Airstream into account and consider the interaction on the base plate, the result of 83% of the participants is sufficient to meet the requirements. Another way to satisfy players is to use technology in puzzle design. This was shown by the results of the tests on the technical requirements. As shown from the interviews, technology has the potential to create a magical moment that enhances the experience. This describes unexpected moments through, for example, automation. The result of the playtest showed that the influence and use of the chosen technology had a positive effect on the experience. During the design process, care was taken to incorporate these so called “wow effects”. Two of these moments that were praised by the participants were the hacking animation and the opening of the house door. Both of these moments are animated events in the puzzle that are triggered by the player but then happen automatically.

The playtest not only showed positive feedback, but also revealed important flaws in the usability of the prototype. Since as a designer you know how to deal with the object you have designed, it is very important to see how participants who have not seen it before act with the prototype. Probably the most important feedback mentioned about the usability of the prototype is the visual feedback in the game. At the time of the playtest, the visual feedback consists of a green LED turning on as soon as the corresponding object has been removed. However, the playtest showed that it is more important to give feedback when the game has been successfully solved and the item is unlocked. This also became clear in the observation when participants solved a part puzzle but did not know that they could now remove the associated object. Therefore, the system is configured so that the LED turns on when the object is unlocked. This should be tested again as it could lead the player to not picking up the object.

Since the entire puzzle consists of three parts, a challenge is to connect the puzzle solutions to the objects on the table. Since the lever of the power plant is in the same fuse box as the oil pump system, there was perceived confusion among the participants who first solved the oil pump puzzle. They thought that there was only one solution in the fuse box and kept on searched for the solution for the power plant. By visually separating the systems (figure 58), they are easier to distinguish.

Prototype during playtest	Prototype with solution (example)
	

Figure 58 - Fuse box (left playtest stage, right improved version)

Another flaw in usability is that was identified during the observation was the ability to rotate the objects. This causes the ring screw to come loose from the wood and clay of the objects. To prevent this, a temporary wooden border was glued to the base plate during the game tests. In future work this will be replaced by a more suitable mechanism. Figure 59 shows the makeshift border .

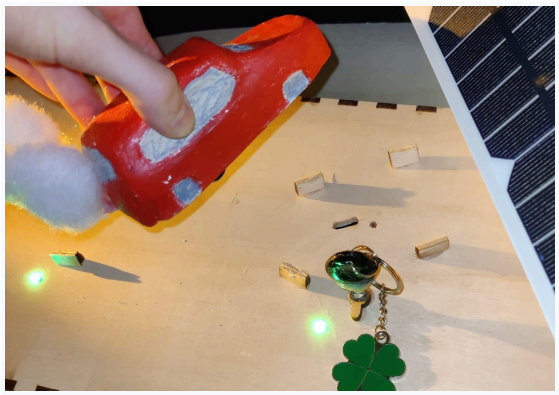


Figure 59 - Wood piece border

The last usability flaw which is a missing requirement is the robustness of the car puzzle. Specifically it is about the car key, which consists of a thin piece of metal and clay. During the tests, the metal piece on the key broke due to strong force in the wrong direction. To prevent

this, the entire mechanism of the lock is reinforced. To do this, a 3D printed part is placed on the potentiometer knob to make it possible to use a thicker piece of metal for the key. Also, the starting position of the lock will not be one of the maximums (right or left) but the middle. This will result in the player getting a feel for how much force is needed to turn the lock. Figure 60 shows the planned reinforcement of the lock detection mechanism of the car puzzle.

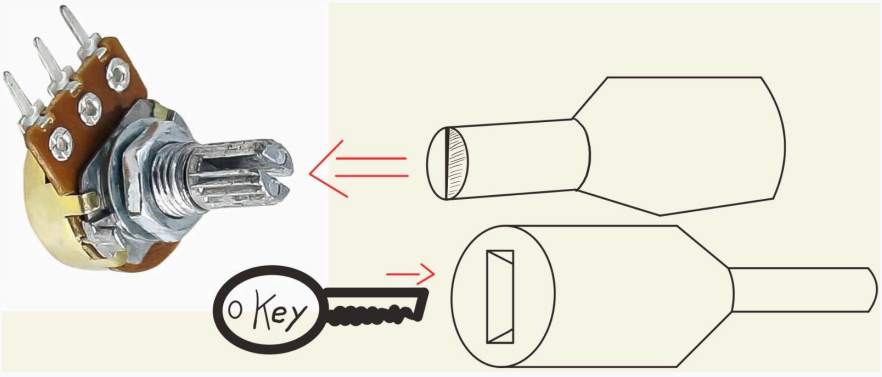


Figure 60 - Attachment for rotary knob

Further feedback from the test relates to possible changes that could be added in the future. On the one hand, attention was drawn to the external appearance of the game, which at the time of testing still very much resembled a prototype due to the wooden look. It has already been changed. The fuse box and the outer edges of the base plate have been given a futuristic technical look in black. Streets and landscapes were painted on the top of the baseplate. This is intended to strengthen the integration into the story and into the player's experience. Another point of feedback from participants is the audio design of the puzzle. Examples such as machine and engine noises were given to bring the objects to life.

To conclude the discussion, a limitation of the amount of testers must be mentioned. The number of participants tested is not meaningful with 12 participants. It is enough to obtain obvious flaws and feedback, however future testing would help to consolidate the results.

The escape room puzzle was removed from the Airstream after the user test in order to incorporate improvements. The puzzle and documentation will be sent to the client by post.

Chapter 9 - Conclusion & future work

In conclusion, this bachelor project aimed to develop and implement a working educational escape room puzzle about the climate crisis that motivates people to learn more about the topics faced while playing the puzzle by answering the question: **How to design a piece for an educational escape room with the topic climate change with the goal of raising awareness and learning motivation about the topic?** Through the background research and the interviews, necessary requirements were established that help to develop a product that serves as an answer to the question. The prototype produced is a sensor-interactive game consisting of three parts which form a chain of puzzles with the intention of triggering excitement and motivation about the topic and motivation to join the workshop. The results show that the prototype was well received by users. They identified the prototype as a motivating and fun activity and appreciated the puzzle chain and the interaction. The user test has produced necessary and possible improvements, the implementation of which will be improved upon in the future. The prototype has successfully achieved the desired requirements, as an interactive, exciting learning experience that motivates. Future work will be to implement visual and audio-visual feedback to clarify gameplay. In order to test the effect on the motivation of the players to take part in the workshop, another play test should be carried out in future work, which includes a pre- and post-test. This would lead to more accurate results. This project provides a detailed overview of a design process of an educational escape room piece given a scenario and limited room such as an airstream caravan. This bachelor project has demonstrated how the technical capabilities of microcomputers can be used to create exciting puzzles and experiences for EERs users. It has provided a valuable contribution to the new use case of escape rooms with the intention of achieving learning objectives and hopefully inspiring impact on game designers and researchers with similar intentions.

When handing over the product, the client receives a document which contains the technical documentation, circuits, code, the puzzle process and the puzzle reset process.

No type of AI was used to create these papers and the product.

Appendix

Appendix 1 - Interview Questions Target group

General Impressions:

1. How would you describe the overall impression of the escape room?

2. What elements or details did you particularly like?

3. Was there something in the room that you didn't like or could be improved?

Theme and Storyline:

1. Can you describe the background story or theme of the escape room?

2. Did the storyline affect your experience in the room or help you immerse yourself in the atmosphere?

Puzzles and Challenges:

1. What types of puzzles and challenges did you encounter in the room?

2. Were there specific puzzles that were particularly tricky or enjoyable?

3. Were you able to successfully solve the puzzles, or did you need assistance?

Team Dynamics and Collaboration:

1. How did your team collaborate in tackling the challenges?

2. Were there specific moments where collaboration was crucial for progress in the escape room?

3. What roles did different team members play?

Technology and Equipment:

1. Were there any technological elements in the escape room that caught your attention?

2. Did the technological setup enhance or influence your experience in the room?

Difficulty Level:

1. How would you rate the difficulty level of the escape room?

2. Were there times when you felt the room was too easy or too difficult?

Surprise Elements:

1. Were there unexpected elements or surprises in the escape room that impressed you?

2. What moments surprised or fascinated you the most?

Room Design and Atmosphere:

1. How would you describe the design of the room and the atmosphere in the escape room?

2. Did the room design contribute to your immersion in the story?

Time Management:

1. How well did you manage the available time in the escape room?

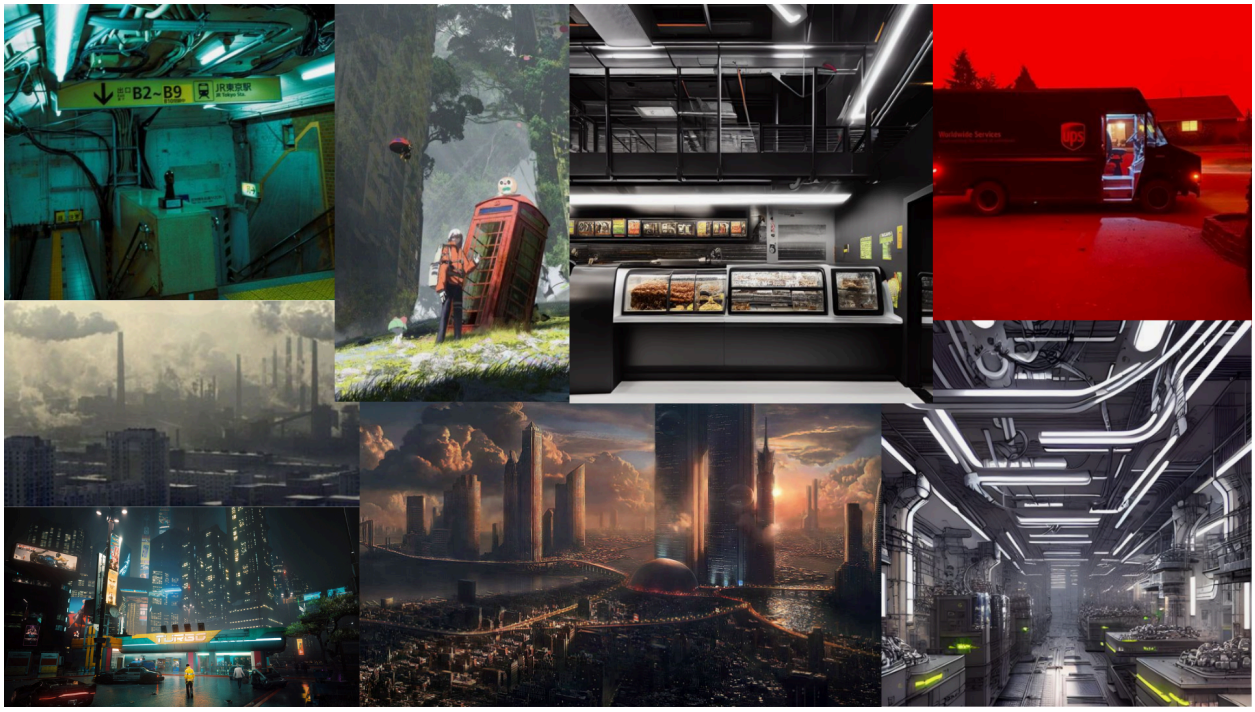
2. Do you feel the provided time was appropriate?

Replay Value and Recommendations:

1. Would you recommend this escape room? Why or why not?

2. Would you visit this room again or try a similar escape room?

Appendix 2 Mind Map Visual



Appendix 3 - Information brochure & Consent Form

Information brochure – Context analysis escape room

A copy of this information brochure can be attained on request to the researcher

Last edited on 6-10-2023

You have been asked to take part in research activities concerning the design of an educational escape room. You will be informed via this information brochure on the topics of the research, the activities, the burdens and risks, the expectations, the consent and the contact information. Your participation is voluntary and you are free to withdraw from participation at any time during the interview and within seven (7) days after the conducted interview.

Aims

This research is conducted in the context of the Bachelor Creative Technology, University of Twente, and the thesis will be about the design of an educational escape room. For the study you have been asked to participate in, the aim is to find the design requirements of the escape room.

Activities

In order to find out what the design requirements of the educational escape room are you will be asked to participate in a semi structured interview. This semi structured interview will take no longer than 45 minutes and will take place either online or in a public space depending on the interviewees preference.

The interview will be recorded using simple recording materials such as a phone microphone or Dictaphone. If the interview is conducted online it will be recorded using only audio. These recordings will be transcribed and added to the bachelor theses of undescribed researchers, personal information will be left out in order to anonymize the data.

Burdens and Risks

The study might impose a small burden regarding the time (around 45 minutes). During the study the participants will not be exposed to dangerous situations or disturbing contents and therefore there is no expected risk regarding the participation in this study.

Expectations

The participants will be expected to truthfully answer questions in a semi structured interview.

Consent

Before participating in the study participants will be asked to fully read the provided information brochure and sign a consent form which will be provided by one of the researchers. Participants can withdraw at any time during the interview and within seven (7) days after the interview without explanation or justification.

Contact

If you have questions about the study please get in touch with one of the researchers who conducted this study. Below you will find the name, email addresses and the spoken languages of the researchers:

Mark Ziegelhöefer
m.j.ziegelhofer@student.utwente.nl
English, German

Arthur van der Torre

a.l.vandervndertorre@student.utwente.nl
English, German, Dutch

Hilke van den Born
h.vandenborn@student.utwente.nl
English, Dutch

If you wish to talk about this research, but not want to talk with one of the researchers mentioned above, please get in touch with the study supervisor dr. Angelika Mader at a.h.mader@utwente.nl .

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science at ethicscommittee-CIS@utwente.nl .

Consent Form for Context analyses educational escape room

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [06/10/2023], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time during the interview and within seven (7) days after the interview, without having to give a reason.	☐	☐
I understand that taking part in the study involves participating in an audio-recorded semi structured interview regarding escape rooms. The audio will be transcribed and personal information will be left out in order to anonymize the data. The audio files will be deleted after the transcription within seven (7) days after the conducted interview.	☐	☐
Use of the information in the study		
I understand that information I provide will be used for the context analysis and the formulation of design requirements. The interview will be transcribed, anonymized and added in the bachelor theses of the undersigned researchers. After a time interval of seven (7) days, the data will be anonymised and the audiofile deleted. The transcript will be guarded safely in a Google Drive map provided by the university and guarded with two factor authentication.	☐	☐

I agree to be audio recorded.	☐	☐

Future use and reuse of the information by others

I give permission for the anonymized (as much as possible) transcription that I provide to be used in the Bachelor theses of undersigned researchers, which will be published in the publicly accessible University of Twente repository (https://essay.uwtente.nl/). The results which will be published in the theses of the undersigned researchers can be used for future learning and research.	☐	☐

Withdrawal of Consent

I understand that I can withdraw from this research at any time during the interview and within seven (7) days after the interview.	☐	☐

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Study contact details for further information

If you have questions about the study please get in touch with one of the researchers who conduct this study. Below you will find the name, email addresses and the spoken languages of the researchers:

Mark Ziegelhöefer
m.j.ziegelhofer@student.utwente.nl
English, German

Arthur van der Torre
a.l.vandervndertorre@student.utwente.nl
English, German, Dutch

Hilke van den Born
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English, Dutch

If you wish to talk about this research, but not want to talk with one of the researchers mentioned above, please get in touch with the research supervisor dr. Angelika Mader at a.h.mader@utwente.nl .

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Appendix 4 Interviews

Participant 1 (Expert interview)::

I: What is your experience with escape rooms?

I have played around 120 commercial rooms. The number is still growing of course. I have a company in which we design escape games or games in general for museums but with a special focus on escape games and escape game mechanics. And I am studying at the moment for my master at university in game design about educational escape games. How we could learn from commercial escape games and use them in education.

I: How would you define an escape room?

So, when you talk about an escape room in the old term, then I would say it is an experience for a group. Normally 2-4 people, sometimes more, sometimes less. You have a defined time limit and most importantly you have a goal you have to achieve to get out. But If I talk now about that I always say, still very important is the team, still very important is the challenge they have to overcome together. The goal so that they know what they have to do. But the time and the space or the room is not that important anymore. So spaces could be just a normal room but they also could be a huge factory hall or a small box or a caravan. So that's not that defined

anymore. Also the time is not. During the early phase it was always 60 minutes but now you have longer games or you have games without any time restriction as well.

I: What is the goal of an escape room from a design perspective?
So for me, it is that who the people play the game have fun together. So that sounds very obvious but if you design serious games or educational games you know that fun is not always that much in the focus. But I think that an escape game is really standing for fun together and achieving something. So if I am designing an escape game I try to have this in my mind. SO: what kind of challenges can I give them, do they have to work together and how can they complete them in a good way? I want them to have a great experience, I want them to finish in a good mood, to be the heroes of the day or what ever the topic of the story is but they should feel good!

I: Can you describe the process of designing an escape room?
I will tell you about when we design an educational escape game because there is a difference there. If I work with clients normally they always have a topic in mind when they come to me. So as a first step we have a workshop where we talk together about their topic and their wishes. Most of the times the topic is very complex so they are thinking about climate change or something like that. So something that is, even if you just hear a talk about an hour about it, it would be hard to understand the whole topic. So if you play a room of an hour, it is even harder. We talk a lot about the topic and we talk about if there are small side stories that are interesting enough, so that we can use them. This is more brainstorming about topic and stories in the first place. Then we have a lot about the space. Because that is the other very important thing for us. If we have to design something that has to be outside we have restriction which are very hard. If it has to be in a permanent environment we have to build in another way that if it is just for an exhibition which is there for about six months. We also know how the light situation is, are we in a fire restricted area? This is something which is always very important. We see if they have enough electronic plug ins, this are always the small things but we have to know that in the first place before we start to really brainstorm. Otherwise you have a great idea and then you realize it wont fit through the door or there is no lift near the exhibition room or whatever. Then we talk about the core questions which they want to have answered. Normally if you work with a museum they already know. I ask them: okay, if the player after one hour player time, walk out of the game what should they remember. What should they tell their coworkers the day after they have played the game? And these questions which they still have in mind after this, are our core questions. When we are designing puzzles or puzzle mechanics we will still always try to remember if these questions are answered by the puzzles. When we have our core questions we will be brainstorming about puzzle mechanics. And we try, which is really hard and it doesn't work at all, all the time. Sometimes it works and that's amazing but we try to find mechanics which fit the thing they should learn. So if they should explore something we try to find the mechanics which is going fully on the exploring part. Or if it is communication, if they have to find clue than we really look to find something to let them feel how it is to find clues. Not just reading stuff but more like hands on. When we have defined the mechanics we would like to use then we are going into to the puzzle creation. Than the most important thing: creating paper prototypes for every puzzle. Very early on in the process. We try to test the puzzles, with friends

mostly and try if they find out what they have to do. We ask them after wards: what do you think we want you to learn by doing this? If their story fits our story than it is perfect. If they tell something completely in a different way than we have to possibly go over it again. We have this feedback loop of trying to make the puzzles better and then we start with the truly designing process. But first paper prototype and the paper prototype has to work, then we can really design a puzzle. There are still problems then. Sometimes the mechanic works perfect in a paper prototype but if you want to build it in a larger scale you realize, oh, it does not work like oh, this RFID is no strong enough to come through the thickness of wood or something like that. Woven through all of these things is the story. So, we have the first brainstorming when we talked about the topic, the stories which are popping up. And all the time when we try to create a puzzle we are challenging if this fits into our very loose but still our over all story. Always ask if it does make sense that the players have to do that at this point in our game.

I: What are elements of an escape room which are necessary for a good user experience?
I think what in a lot of educational escape games are missing, which are normal in commercial escape games is emotional tension. Normally I only see tension because you have a time limit but if you want a really nice game, you also want tension because the story is moving on. Or just the in group pressure like: We should do that now! Or what ever. I think that is something that is, for me, a key factor in every escape game. And the tension does not have to be that hard or all the time. You have to find a balance, how to bring the players through the game. Also emotion. Because I believe that a lot of educational escape games are more like a test in the school. So if you solve it right, than you are the winner, yay. But I think that in this medium it is so much communication and working together that emotion could be so helpful. It is also very good for learning experiences. It believe that these are the keys in every escape game that you think about which emotions players should have and at which points. So how could we reward them, or how could we stress them out for a moment and then release them again so they have this roller coaster of emotions. I already said communication. It does not work if there is no communication within the groups. However, it could be an interesting moment if you play with that so they can’t communicate for a certain amount of time and then they could. That could be very interesting. Again emotions.

I: What are elements of an escape room, which in your opinion, do not work well?
So you heard it probably already but I think that red herrings are a no go because if I watch players play, they always find their own red herrings. They are already confused so if I try to confuse them even more than I am not a good game designer, in my opinion. The other thing is that very often it is not clear for the player on what type of puzzle they are working on. So if they know what pieces they need and what puzzles they work on or what the way is, or what the goal is, the flow is much better. They will just go on and very often in games that I consider as not so good we were struggling by: ‘What is the thing that we are working on at the moment? A lot of game designers think that they should make the puzzles difficult or if it is too easy for the players to find out which part is working, than the whole thing is too easy. But in my opinion it is not. If you want to create a great flow and atmosphere than you need the players to move on the whole time and have ideas and be inspired. Frustration is a part, you should not avoid frustration at all but only use it small parts and not ten minutes long for the same puzzle.

I: What are challenges you might face during the design of an escape room?
The true answers is normally money and time. It is very often in our kind of creative process. If you normally design a commercial room, you have to rent the room already long before you can open. That is a financial problem. In addition, you face restrictions from the room or the caravan or what ever which you really should have in mind from the beginning. That is also a thing, a lot of first designers kind of forget about it until they realize: ‘Oh yeah, there are some fire restrictions’. Keeping all of that in mind is important. You are always very inspired by creating the story and making the puzzle but the hard facts, you cannot deny during the process. To keep them on the map, be consistent with them. Do not lie to yourself about them, you cannot change them so accept them and involve them in your process. I also see that most game designers should test more. We always test not enough even if we test a lot. Because normally you have a date where you want to open. And you have, in your plan, that your last 3 or 4 weeks are for testing and adapting. Just testing would be nice but you still have to adapt it, so four weeks is a little short. The real life appears and the four weeks shrink together to two weeks or one and a half weeks until the opening. Then you normally conduct a test weekend and that is mostly not enough. I would say, if you design an escape game, take more then four weeks for the testing period. Than it will, in the end, around three weeks of testing.

I: Which educational advantages could escape rooms have in your opinion?
I just talked with my coworker about that because she is a teacher in primary school. She told me that at the moment in schools, there is a lot going on about soft skills. So the students should learn about how to communicate, how to get over frustration, how to find new ways around a problem, how to work in a group. All these things, and even sometimes just how to make a knot, or how to open a knot, how to read a map or something like that. I think educational escape games are perfect for that. The are also very good for the students who are normally not the stars of the class, since they could shine. Maybe their idea is the perfect idea, or maybe they have an input to the group which helps the group going forward. I think that is perfect. It helps also to break down the normal school working day. It could also just be good for teamwork exercises and it gives a new perspective on the topic or a first impression of a topic. I also that that a lot of educational escape games do not do enough is debriefing in the end. Talk to the students about what they have experienced. What emotions did they have about that? You will have talks with them about the topics, sometimes even talks about very deep topics which you normally would not have.

I: We are designing a mobile escape room in a Airstream caravan, are there any challenges you foresee? There are some challenges!
The first thing I think which I already said is that you have a car that is moving in between the games. You have to think about how to make everything not moving due to the drive. Also, how to design it that the players will not think that your measurement to keep everything in place are part of the puzzle. The Airstream will probably not be insulated very good, I am not sure about that but it might be very cold in winter and very warm in summer. If you work with technical stuff like Arduinos really make sure that the Arduino can handle the temperature changes. You also have a tight space. Hiding stuff, under the floor, the ceiling can be a problem. You cannot bring

in a second ceiling to hide everything the player should not see. All the cables have to be hidden, this might be difficult. You also only have one room. You could find solutions by splitting the caravan into smaller pieces or to build some cupboard which can be locked and opened. It is really fun to find ways to create spaces that the player did not expect: under the sofa, the bed or what ever is in there. That is really nice! It is hard to do! There will probably be also some kind of problem with humidity. If it is raining outside the air in the caravan can get very humid and cause mold and deformation problems within wooden objects. So things which can normally open without a problem, might not open at all due to moisture deformation. Please test your puzzles in different conditions. The opportunity to move around sounds like a lot of problems but there is also a lot of good stuff going on here! There is a chance of a really really nice escape room due to the caravan!

I: What adaptations need to be made in order to create an escape room in a limited space?
We normally tend to forget about the sizes during the creation process. The space is always bigger in our mind, but the physical objects always takes up more space than expected! I would say: being very close to the room or the space or the box is important. Always directly check if it really fits in, it is very important and helpful. Try to make rough models of the sizes that are available for you!

Appendix 5 Survey playtest

Escape room playtest survey for Mark

Welcome to the feedback form for our Educational Escape Room project! We value your time and your opinion. This escape room was designed to provide a fun and educational experience.

This form is for the game on the table to the right side of the airstream.

Please take a moment to answer the following questions. Your feedback is valuable and helps improve the gaming experience.

Due to the multilingual nature of the participants, the survey will be conducted in English.

Thank you in advance for your participation!

1. What is the topic of the general **escape room**? (text answer)
2. What is the topic of the **table game**? (text answer)
3. How long did it take you to complete the game? Please guess. (in numbers from 0-90 min.)
4. I recognized the theme of the **table game**. (1-5 scale)
5. How would you rate the overall difficulty of the **table game**? (1-5 scale)
6. How do you rate the entertainment value of the **table game**? (1-5 scale)
7. The amount of physical input in the **table game** helped us feel actively involved. (1-5 scale)

8. How obvious did you find the connection between the fuse box and the **table game**? (1-5 scale)
9. What troubles did you encounter while(technical, cognitive, etc.) solving the power plant puzzle? (text answer)
10. What troubles did you encounter while(technical, cognitive, etc.) solving the oil pump puzzle? (text answer)
11. What troubles did you encounter while(technical, cognitive, etc.) solving the sport car puzzle? (text answer)
12. After playing the **table game** I feel more motivated to join the workshop about the climate crisis? (1-5 scale)
13. How did the incorporation of technology contribute to your overall experience during the **table game**? (text answer)
14. Which elements of the game did you find particularly challenging? (text answer)
15. Which elements of the **table game** were the most enjoyable? (text answer)
16. Would you recommend the **table game** to others? Why or why not? (text answer)
17. What would you improve about the **table game** if you had the chance? (text answer)
18. Is there anything else you would like to say about the **table game**? (text answer)

Appendix 6 Interview questions Gamemaster/Expert

1. What is your job as a gamemaster?
2. What do you have to pay attention to as a gamemaster?
3. How is the Gamemaster program structured?
4. What is important to mention in an introduction for customers?
5. What are the rules?
6. Why do you also use a direct voice connection?
7. What is the purpose of clues?
8. Is it difficult to give the right clues?
9. How are your rooms structured?
10. What do you value when designing an escape room?

Appendix 7 Interview questions and answers Project team

R1
I: Was ist Ihre Funktion in dem Projekt?

Meine Funktion ist, dass ich der Projektleiter bin von dem Airstream Projekt, und ich bin auch der einzige, der es finanziert.

I: In welcher Designs Phase befinden Sie sich mit Ihrem Projekt?

Ungefähr zwischen den ersten drei. Emphasise haben wir fertig. Leider haben wir es nicht genau wissenschaftlich begangen, also wurden sie nicht seriell abgearbeitet, aber eher willkürlich. Die ersten drei wurden schon mal angefangen, aber keine ist jetzt wirklich ganz fertig.

I: Welche Schwierigkeiten beim Bau der Einrichtung haben Sie bisher überwunden?

Als erstes musste der Wagen transportbereit gemacht werden, also das die Einrichtung belebbar war und das der Wagen fahren konnte, sagen wir mal die basics der basics. Weiter haben wir auch die Designgrundlagen können belegen, also Solarpunk halt, das ist uns auch gelungen. Weiter haben wir auch Stromversorgung eingerichtet, dass alle Lebensnotwendigkeiten versorgt werden, so wie duschen und so, das haben wir alles hingekriegt ja.

I: Welchen Entwurfsprozess verfolgen Sie?

Wir haben einen Gamemaster, der von mir selbst bezahlt wird, der sich mit dem Design beschäftigt, Vor ihm war auch noch ein anderer aus einem Verein, der sich auch damit auseinandergesetzt hat. Die sind transparent damit, weil ich das auch selber spannend finde, aber ich glaube die verfolgen eher keine Prozedur so wie sie jetzt ein Akademiker geschrieben und bewiesen hat, ich glaube die bauen eher auf ihre Erfahrungen von was funktioniert und was funktioniert nicht. Abe auch sie haben etwas genannt in der Richtung von Evaluierung, dass man sich immer eine zweite Meinung holen soll, kann ja zum Beispiel sein, dass man glaubt, eine Idee ist sehr gut und dann gesagt bekommt, war langweilig, und dass dann in der Tat auch Ideen gekillt werden müssen, haben wir schon oft miterlebt. Wir haben schon rapid Prototyping Sessions unternommen, also sind alle mal zusammengekommen und haben mit Pappe par Ideen generiert, da haben wir gemerkt, dass wegen denen verschieden Hintergründen nicht jeder so schnell eine Idee bedenken kann. Das Gamedesign doch schwerer ist als man denkt, haben wir auch festgestellt ja.

I: Für welche Benutzererfahrungen entwerfen Sie? (Was soll der Besucher fühlen und wann?)

Es gibt drei Gruppen von Kunden: Ein Staat, wo dann für eine gewisse Zeit der Bus auf einem Plaza steht und von dem Publikum besucht werden kann, individuelle Gruppen, die den Escape Room für eine Stunde buchen können und als letztes Unternehmen, die sich transformieren wollen und mit dem Airstream spielerisch erfahren wollen, wie man klimabewusst handeln kann. Und weiter auch noch edukative Einrichtungen sowie Schulen und so, aber keine Kinder, das ergibt Problemen mit denen Eltern und shocking Material, also die User sind immer Erwachsene über 16. Also die Kunden sind Business und die User sind dann die Erwachsenen.

I: Wie haben die Endnutzer bisher auf den Prototyp des Busses reagiert?

Der Aistream zieht Menschen an wie Licht Insekten, es hat eine sehr spezielle, ungewohnte Form, sieht aus wie aus der Zeit gefallen.Es ist ja ein sehr besonderes Model was heutzutage nicht mehr hergestellt wird, mit einer ikonischen Form die an Flugzeugbau erinnert Das ist der erste Eindruck. Der zweite Eindruck ist enttäuschung so von “Ach so, der ist noch gar nicht fertig, ich kann ihn noch nicht spielen.” Aber wir haben noch gar keine Ablehnung bekommen, immer wenn Menschen den Airstream besuchen, sind sie positiv, bieten auch gerne mal an, mitzuhelfen, sagen dass ihnen die Form sehr gefällt. Es hat ja auch etwas mysteriösisches, irgendetwas mit Fliegerei.

I: Wie viel Erfahrung haben Sie persönlich mit Technologie?

Also ich bin keine Technical Person, ich bin eine Person Person. Was ich gut kann, ist hoch performante Teams zusammenstellen. Ich bin weiter auch gut darin, user journeys zu evaluieren, weil ich mich gut in die Schuhe des Nutzers setzen kann. Also ich besitze eine bestimmte Beurteilungskompetenz, kann's aber nicht selbst bauen, wenn das die Frage ist.

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I: Wie stellen Sie sich den endgültigen Escape Room vor?

Es soll ein tolles Spielerlebnis sein, wo eine Gruppe in 60 Minuten ein Rätsel lösen soll. Thema ist halt Klimawandel, eine Klimakrise in der wir alle stärker ins handeln kommen sollen. Dieser Raum, den gibt es, um die Wahrscheinlichkeit, dass jemand in seinem Alltag anders handelt, nur um einen mili Prozent, mal bescheiden, zu erhöhen. Also, dass die Informationen, die eine Person in diesem Escape Room mit sich nimmt, dann später zum Beispiel in einem Unternehmen, wenn ich wählen kann zwischen A und B, dass ich dann mehr richtung B kippe. Und das schönste wäre natürlich, wenn Menschen dadurch inspiriert werden könnten. Also, das ist ungefähr der Why es diesen Raum gibt.

I: Welche räumlichen Anforderungen haben Sie für jedes einzelne Escape-Room-Rätsel?

Wie du siehst, ist die originale Kern Einrichtung erhalten, so der Ofen, der Kühlschrank und so. Ich könnte mir gut vorstellen, dass solche Plätze geeignet wären für Puzzles. Wäre wahrscheinlich gut, wenn irgendwie Themen behalten, so wie ein Ofen zum Beispiel etwas mit Hitze zu tun hat, und ein Kühlschrank etwas mit Ernährung. Ich fände es selbst interessant, wenn diese Orte auch selbst eine Transformation untergehen würden, so wie der Rest des Raums. Wir dachten weiter auch übrigens darüber nach, um wieder eine Trennung einzuführen. An diesen Orten da gab es zwei Türen, die wie entfernt haben, weil der Raum sonst zu klein war für vier, aber ich könnte mir gut vorstellen, dass das für Spieler spannend und motivierend ist, wenn sie merken: Hey, der war doch von außen größer!", und sich dann in den letzen Raum begeben müssen. Aber ansonst, Boden, Decke, nichts ist ausgeschlossen, alles ist nutzbar.

I: Was sind die visuellen oder gestalterischen Anforderungen für jedes Rätsel? (Wie muss es (nicht) aussehen)

Also der Style soll halt ganz deutlich Solarpunk sein, das ist ein älteres Konzept was sich auf die Versöhnung zwischen Technologie und Natur bezieht. Auch in einer solchen Welt kann man teil der Lösung sein, aber auch Teil des Problems, aber was mir sehr gefallen würde, wäre wenn zum Beispiel das ein Computer, oder eine Maschine so aussieht, als hätte sie Blätter. Und eher neues plastik meiden, ausser wenn es nicht anders gänge. Wir haben den Wagen erst mal weis angemalt, und versuchen in der richtung von weis, grau und grün zu bleiben. Dann sticht eine Rote Lampe auch mehr heraus, und können Spieler besser geleitet werden für Hints, kann ich mir vorstellen. So können Signalfarben dann punktuell eingesetzt werden. Was ich mir hier nicht vorstellen kann, wären größe Flächen von Rot und Gelb und so, das würde Solarpunk ziemlich widersprechen. Silber ist auch ne tolle Farbe, weil der Bus selbst ja auch silber ist, aber eher puristisch mit den Farben stell ich mir das vor.

I: Wie hoch sollte Ihrer Meinung nach die Produktionskomplexität eines jeden Rätsels sein? (Wie viel Technik können Sie bewältigen)

Also, es wird ja schlussendlich etwas sein zum Anfassen und Angrabbeln, deswegen spielt die Robustheit eine große Rolle. So wenig wie möglich soll absteckbar sein, weil wenn sie können,

machen Menschen alles kaputt. Ich hab selbst auch während dem Prototyping Sachen versehentlich kaputt gemacht, das passiert. Man könnte ja zum Beispiel etwas Zerbrechliches auch hinter Plexiglas verstecken, so dass die halt nicht rankommen. Da würde ich sagen, liegt die Komplexität eher im hinteren Vorhang. Das Schlimmste wäre natürlich, wenn ein Rätsel jetzt ausfällt und nichts mehr geht, dass das ganze Spiel platt geht. Da wäre es gut, einen Work-around zu haben, dass es noch klappen würde, zum Beispiel der Gamemaster eine Kode bekommt und die weitergibt an den Spieler.

I: Was sind weitere Anforderungen, die Sie nennen könnten?

Ich bin ja beruflich Klimaadviseur und sag immer: “Klimakrise ist Kommunikationskrise.”. In unserem Alltag hören wir schon genug über die Klimakrise, wir haben festgestellt, dass mit der Pädagogik sich nur noch die wenigsten darauf einlassen, und leider nicht die, die wir erreichen wollen. Das ist der Grund, warum wir durch Spiel eine Intuition aufbauen möchten, es soll nicht nur von Fakten ausgehen, also eher spannend und kurzweilig. Der Spaß soll nie unter der Komplexität gestellt werden, es soll in dem Sinn nicht unbedingt ein informativer Escape Room werden, dann hätte ich lieber etwas weniger Informationen darin verwebt, als dass jetzt der Spaß aufgegeben wird.

I: Wie langlebig und robust sollte das Puzzle sein (Wie oft soll es benutzt werden)?

Also, es soll so robust wie möglich sein. Soll runterfallen können und nicht direkt kaputtgehen, oder wenn jemand drauf tritt. Es soll auch schon reproduzierbar sein, nicht dass, wenn etwas zerbricht, es nicht mehr hergestellt kann werden. Sollte auch keine großartige Neuprogrammierung benötigen die wir nicht untergehen können. Also, wir rechnen damit um ungefähr 3-5 Jahre konstantes Nutzen, für diese Zeit soll es halten und gut funktionieren. Nach diesem Zeitpunkt werden wir auch versuchen, zu Scalen, also wäre schön, wenn es abwärtskompatibel wäre, aber dies muss nicht unbedingt sein.

I: Inwieweit sollten die Materialien des Puzzles austauschbar sein?

Es gibt bei uns Menschen in der Gruppe, die könnten so etwas wieder reparieren, aber generell, jeh einfacher desto besser. Es soll auch eine Minimalanforderung sein, dass eine Dokumentation dabei ist, der ein normal sterblicher Mensch begreifen kann. Also, je weniger, desto besser.

I: Inwieweit sollte das Puzzle reparierbar sein?

Ja, soll reparierbar sein. Entweder es soll eine Möglichkeit geben, dass das Spiel weitergehen kann ohne dem Puzzle oder halt ein Work-around.

I: Was ist die Atmosphäre, die Sie für die Erfahrung schaffen wollen?

Es soll ja schlussendlich mit Solarpunk, also die Wiederversöhnung von Mensch und Technik zu tun haben. Es wird so sein, dass sie in einem dunklen Raum treten werden, dann gehen langsam die Lichter an, also so Tension halt. Wir könnten auch so LED streifen verwenden um in der Dunkelheit zu leiten. So, ich denk grad halt nach, ne. Was wichtig ist, der Airstream ist ja ein Reisemobil, so symbolisiert ja eine Art reise, und das soll sich irgendwie auch widerspiegeln, dieses Reisegefühl. Eine solche Reise kann ja örtlich sein, kann aber auch zeitlich sein. Dann wäre es auch eine Idee, um irgendwo ein Art Reisetagebuch oder so zu

bewahren, wo man dann über all die verlorenen Plätze lesen kann. Also das Thema einer Art Reise soll schon aufgefangen werden. Ich kann mir auch vorstellen, dass Räume sich über Zeit verändern werden, durch die Zeitreise. So kann man sich fragen, wie sieht dieser Ort aus in 40 Jahren. Wir hatten die Idee, um lauter screens vor dem Fenster zu hängen, dann könnte man so sehen: “Ach, die Kirche da, die ist jetzt anders”, oder so.Also, so impliziert es das Gefühl von Reise irgendwie an. Eine Zeitreise ist ja eigendlich einen Sprung, man ist auf einmal von einem Ort in den nächsten. Da gab es auch lauter Zeitreisparadoxen, die wir noch nicht gelöst haben, jetzt machen wir das mal mit dem Video so. Impliziert soll das Gefühl von Reise präsent sein. Dann fragt man sich natürlich auch, welche Reise, zum Beispiel das Idee mit der Seele, ist auch ne Reise irgendwie. Hat was mit Mysterium. Darum, irgendwie wäre es schön, wenn das Thema Reise darin verwoben wäre.

I: Was ist der "rote Faden" des Puzzles innerhalb der Installation?

Also, Spaß un Unterhaltsamkeit wären schon mal die ersten. In 60 minuten die Rätsel lösen und dabei ein gutes Gefühl erzeugen, zusammen Spaß haben wäre eine. Dann gibt es ja auch einige Themen, die stets zurückkehren, so wie halt Thema Klima, und das kann dann sein in der Form von Ressourcen, also Wasser undso, kann aber auch Umwelt sein, das Verhältnis als Spezies zur Umwelt könnte auch was sein, ne. Und auch das Thema reisen soll halt an manchen Orten spürbar sein. Der letze Link wäre dann, wie bekommen wir die Botschaft implizit rüber. Ich glaube, wir machen das mit dem Thema reisen, hängt das so zusammen. Wenn jetzt einer sagt “Hey, wir Menschen sind am sterben, ihr müsst euer Benehmen ändern”, da hat kein Mensch Bock drauf. Deswegen sollen alle Puzzels diese Botschaft irgendwie implizit, und indirekt rüberbringen. Die Frage ist dann natürlich, wie kann sie in so einem Puzzel eingepackt werden, ohne dass es aufdringlich rüberkommt.

I: Gibt es etwas, das Sie dem Gesagten noch hinzufügen möchten?

Ja, es ist wichtig, dass ihr die Ideen, die ihr habt, schon mal in der Gruppe andockt, damit wir anfangen können, produktiv zu prototypen. Also, wir treffen uns ja am 27. Oktober, es wäre gut, wenn ihr dann schon eine gewisse Idee, also besser 3 sogar, was ihr zusammenstellen möchtet, damit wir die Rätselhierarchien bestimmen können. Also, das wären dann die Interfaces, die Orte und der Input-Output.

I: Vielen Dank für Ihre Zeit.

Appendix 8 Interview Escape room designer

P1:

I: What is your experience with escape rooms?

I have played around 120 commercial rooms. The number is still growing of course. I have a company in which we design escape games or games in general for museums but with a special focus on escape games and escape game mechanics. And I am studying at the moment for my master at university in game design about educational escape games. How we could learn from commercial escape games and use them in education.

I: How would you define an escape room?

So, when you talk about an escape room in the old term, then I would say it is an experience for a group. Normally 2-4 people, sometimes more, sometimes less. You have a defined time limit and most importantly you have a goal you have to achieve to get out. But If I talk now about that I always say, still very important is the team, still very important is the challenge they have to overcome together. The goal so that they know what they have to do. But the time and the space or the room is not that important anymore. So spaces could be just a normal room but they also could be a huge factory hall or a small box or a caravan. So that's not that defined anymore. Also the time is not. During the early phase it was always 60 minutes but now you have longer games or you have games without any time restriction as well.

I: What is the goal of an escape room from a design perspective?

So for me, it is that who the people play the game have fun together. So that sounds very obvious but if you design serious games or educational games you know that fun is not always that much in the focus. But I think that an escape game is really standing for fun together and achieving something. So if I am designing an escape game I try to have this in my mind. SO: what kind of challenges can I give them, do they have to work together and how can they complete them in a good way? I want them to have a great experience, I want them to finish in a good mood, to be the heroes of the day or what ever the topic of the story is but they should feel good!

I: Can you describe the process of designing an escape room?

I will tell you about when we design an educational escape game because there is a difference there. If I work with clients normally they always have a topic in mind when they come to me. So as a first step we have a workshop where we talk together about their topic and their wishes. Most of the times the topic is very complex so they are thinking about climate change or something like that. So something that is, even if you just hear a talk about an hour about it, it would be hard to understand the whole topic. So if you play a room of an hour, it is even harder. We talk a lot about the topic and we talk about if there are small side stories that are interesting enough, so that we can use them. This is more brainstorming about topic and stories in the first place.

Then we have a lot about the space. Because that is the other very important thing for us. If we have to design something that has to be outside we have restriction which are very hard. If it has to be in a permanent environment we have to build in another way that if it is just for an exhibition which is there for about six months. We also know how the light situation is, are we in a fire restricted area? This is something which is always very important. We see if they have enough electronic plug ins, this are always the small things but we have to know that in the first place before we start to really brainstorm. Otherwise you have a great idea and then you realize it wont fit through the door or there is no lift near the exhibition room or whatever.

Then we talk about the core questions which they want to have answered. Normally if you work with a museum they already know. I ask them: okay, if the player after one hour player time, walk out of the game what should they remember. What should they tell their coworkers the day after they have played the game? And these questions which they still have in mind after this, are our core questions. When we are designing puzzles or puzzle mechanics we will still always try to remember if these questions are answered by the puzzles.

When we have our core questions we will be brainstorming about puzzle mechanics. And we try, which is really hard and it doesn't work at all, all the time. Sometimes it works and that's amazing but we try to find mechanics which fit the thing they should learn. So if they should explore something we try to find the mechanics which is going fully on the exploring part. Or if it is communication, if they have to find clue than we really look to find something to let them feel how it is to find clues. Not just reading stuff but more like hands on.

When we have defined the mechanics we would like to use then we are going into to the puzzle creation. Than the most important thing: creating paper prototypes for every puzzle. Very early on in the process. We try to test the puzzles, with friends mostly and try if they find out what they have to do. We ask them after wards: what do you think we want you to learn by doing this? If their story fits our story than it is perfect. If they tell something completely in a different way than we have to possibly go over it again.

We have this feedback loop of trying to make the puzzles better and then we start with the truly designing process. But first paper prototype and the paper prototype has to work, then we can really design a puzzle. There are still problems then. Sometimes the mechanic works perfect in a paper prototype but if you want to build it in a larger scale you realize, oh, it does not work like oh, this RFID is no strong enough to come through the thickness of wood or something like that.

Woven through all of these things is the story. So, we have the first brainstorming when we talked about the topic, the stories which are popping up. And all the time when we try to create a puzzle we are challenging if this fits into our very loose but still our over all story. Always ask if it does make sense that the players have to do that at this point in our game.

I: What are elements of an escape room which are necessary for a good user experience?

I think what in a lot of educational escape games are missing, which are normal in commercial escape games is emotional tension. Normally I only see tension because you have a time limit but if you want a really nice game, you also want tension because the story is moving on. Or just the in group pressure like: We should do that now! Or what ever. I think that is something that is, for me, a key factor in every escape game. And the tension does not have to be that hard or all the time. You have to find a balance, how to bring the players through the game.

Also emotion. Because I believe that a lot of educational escape games are more like a test in the school. So if you solve it right, than you are the winner, yay. But I think that in this medium it is so much communication and working together that emotion could be so helpful. It is also very good for learning experiences. It believe that these are the keys in every escape game that you think about which emotions players should have and at which points. So how could we reward them, or how could we stress them out for a moment and then release them again so they have this roller coaster of emotions.

I already said communication. It does not work if there is no communication within the groups. However, it could be an interesting moment if you play with that so they can't communicate for a certain amount of time and then they could. That could be very interesting. Again emotions.

I: What are elements of an escape room, which in your opinion, do not work well?

So you heard it probably already but I think that red herrings are a no go because if I watch players play, they always find their own red herrings. They are already confused so if I try to confuse them even more than I am not a good game designer, in my opinion.

The other thing is that very often it is not clear for the player on what type of puzzle they are working on. So if they know what pieces they need and what puzzles they work on or what the way is, or what the goal is, the flow is much better. They will just go on and very often in games that I consider as not so good we were struggling by: 'What is the thing that we are working on at the moment? A lot of game designers think that they should make the puzzles difficult or if it is too easy for the players to find out which part is working, than the whole thing is too easy. But in my opinion it is not. If you want to create a great flow and atmosphere than you need the players to move on the whole time and have ideas and be inspired. Frustration is a part, you should not avoid frustration at all but only use it small parts and not ten minutes long for the same puzzle.

I: What are challenges you might face during the design of an escape room?

The true answers is normally money and time. It is very often in our kind of creative process. If you normally design a commercial room, you have to rent the room already long before you can open. That is a financial problem. In addition, you face restrictions from the room or the caravan or what ever which you really should have in mind from the beginning. That is also a thing, a lot of first designers kind of forget about it until they realize: ‘Oh yeah, there are some fire restrictions’. Keeping all of that in mind is important. You are always very inspired by creating the story and making the puzzle but the hard facts, you cannot deny during the process. To keep them on the map, be consistent with them. Do not lie to yourself about them, you cannot change them so accept them and involve them in your process.

I also see that most game designers should test more. We always test not enough even if we test a lot. Because normally you have a date where you want to open. And you have, in your plan, that your last 3 or 4 weeks are for testing and adapting. Just testing would be nice but you still have to adapt it, so four weeks is a little short. The real life appears and the four weeks shrink together to two weeks or one and a half weeks until the opening. Then you normally conduct a test weekend and that is mostly not enough. I would say, if you design an escape game, take more then four weeks for the testing period. Than it will, in the end, around three weeks of testing.

I: Which educational advantages could escape rooms have in your opinion?

I just talked with my coworker about that because she is a teacher in primary school. She told me that at the moment in schools, there is a lot going on about soft skills. So the students should learn about how to communicate, how to get over frustration, how to find new ways around a problem, how to work in a group. All these things, and even sometimes just how to make a knot, or how to open a knot, how to read a map or something like that. I think educational escape games are perfect for that. The are also very good for the students who are normally not the stars of the class, since they could shine. Maybe their idea is the perfect idea, or maybe they have an input to the group which helps the group going forward. I think that is perfect. It helps also to break down the normal school working day. It could also just be good for teamwork exercises and it gives a new perspective on the topic or a first impression of a topic.

I also that that a lot of educational escape games do not do enough is debriefing in the end. Talk to the students about what they have experienced. What emotions did they have about that? You will have talks with them about the topics, sometimes even talks about very deep topics which you normally would not have.

I: We are designing a mobile escape room in a Airstream caravan, are there any challenges you foresee?

There are some challenges! The first thing I think which I already said is that you have a car that is moving in between the games. You have to think about how to make everything not moving due to the drive. Also, how to design it that the players will not think that your measurement to keep everything in place are part of the puzzle.

The Airstream will probably not be insulated very good, I am not sure about that but it might be very cold in winter and very warm in summer. If you work with technical stuff like Arduinos really make sure that the Arduino can handle the temperature changes.

You also have a tight space. Hiding stuff, under the floor, the ceiling can be a problem. You cannot bring in a second ceiling to hide everything the player should not see. All the cables have to be hidden, this might be difficult.

You also only have one room. You could find solutions by splitting the caravan into smaller pieces or to build some cupboard which can be locked and opened. It is really fun to find ways to create spaces that the player did not expect: under the sofa, the bed or what ever is in there. That is really nice! It is hard to do!

There will probably be also some kind of problem with humidity. If it is raining outside the air in the caravan can get very humid and cause mold and deformation problems within wooden objects. So things which can normally open without a problem, might not open at all due to moisture deformation. Please test your puzzles in different conditions.

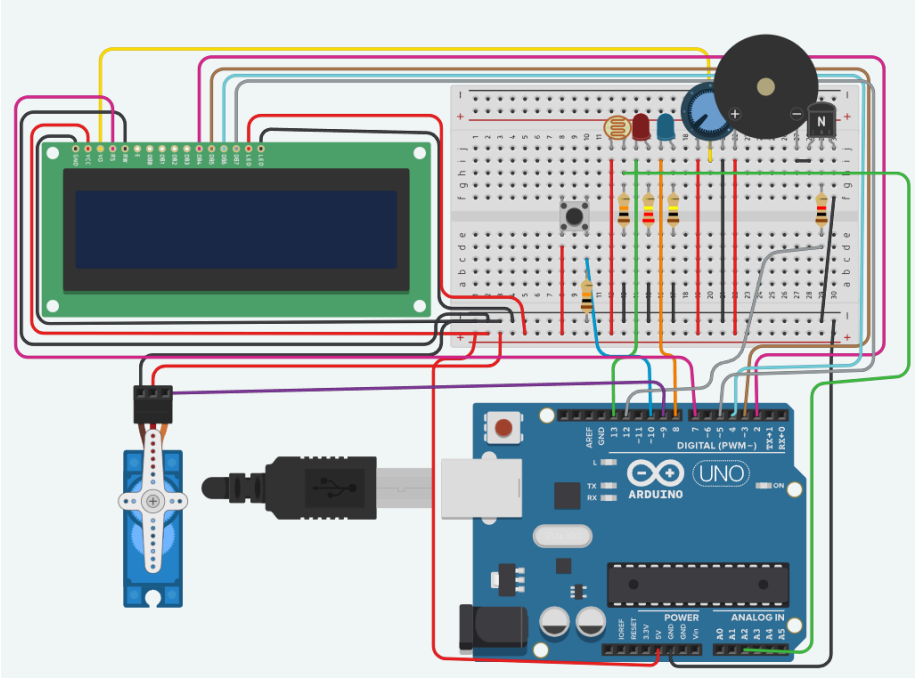
The opportunity to move around sounds like a lot of problems but there is also a lot of good stuff going on here! There is a chance of a really really nice escape room due to the caravan!

I: What adaptations need to be made in order to create an escape room in a limited space?

We normally tend to forget about the sizes during the creation process. The space is always bigger in our mind, but the physical objects always takes up more space than expected! I would say: being very close to the room or the space or the box is important. Always directly check if it really fits in, it is very important and helpful. Try to make rough models of the sizes that are available for you!

Appendix 9 Schematics

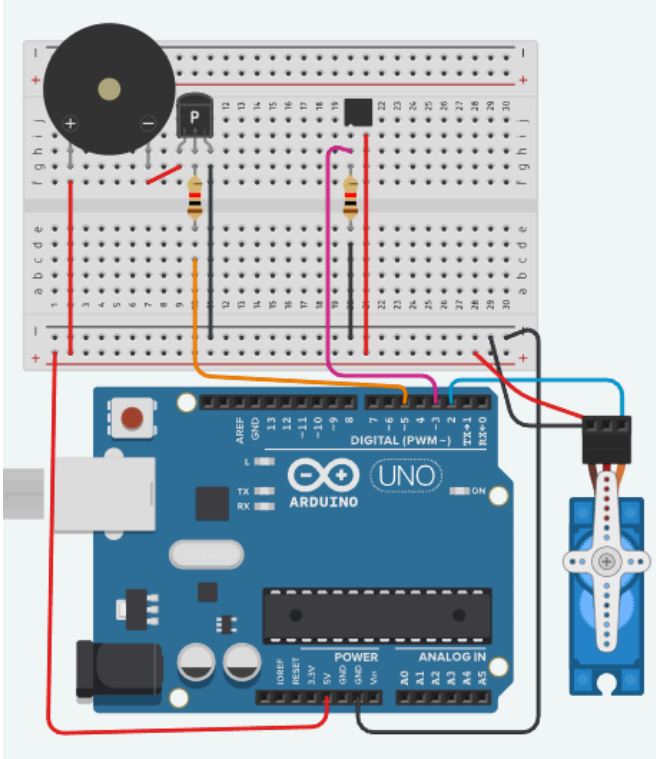
Oil pump Circuit



List of components:

- Arduino UNO
- Tower pro servo motor
- Red LED
- Green LED
- Potentio meter
- Button
- BC337 transistor
- Piezo beeper
- LDR

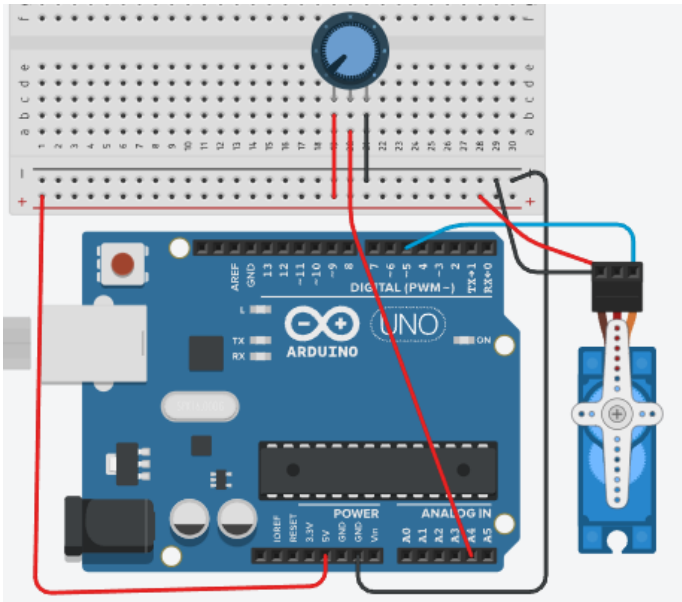
Power plant



List of components:

- Arduino UNO
- Tower pro servo motor
- BC337 transistor
- Piezo beeper
- Tilt sensor

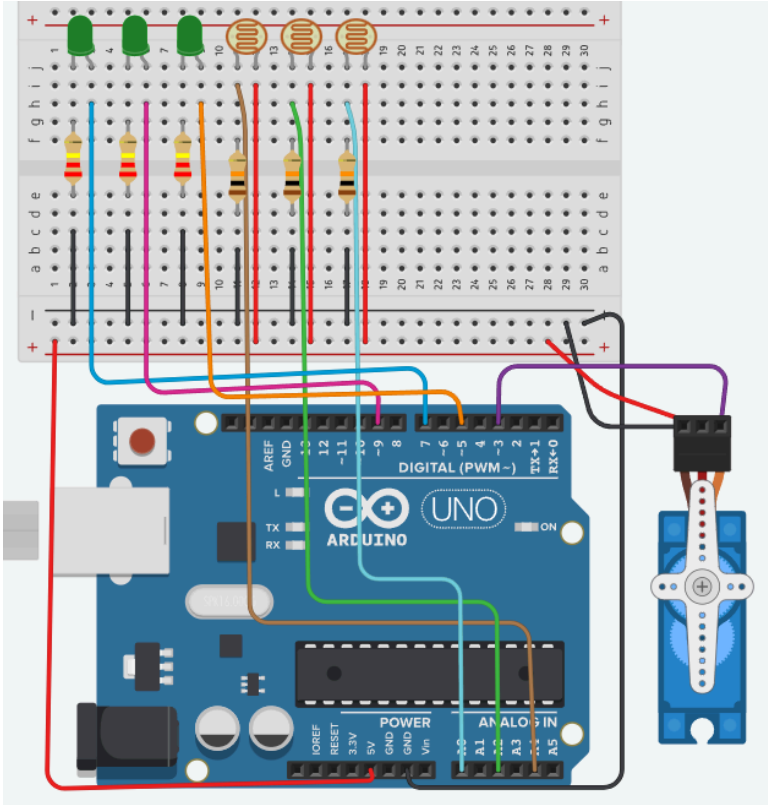
Car puzzle



List of components:

- Arduino Nano
- Tower pro servo motor
- Potentio meter

Base plate



List of components:

- Arduino Nano
- Tower pro servo motor
- 3x Green LED
- 3x LDR

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