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Exploring design guidelines to teach young children about potential frightening topics through a digital interactive experience

Master's thesis in Computer science and engineering

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Abstract

There is difficulty explaining to children why the world might be changing, whether it's because of a pandemic, catastrophe, or other potentially frightening topics. Still, when children's lives become affected, guardians and teachers might have no choice but to try and explain these sensitive topics in an emotionally considerate manner without many digital sources as support. Through an exploratory research approach, this project aimed to discover suitable ways to present potentially frightening topics to young children. During the process, the team designed "Pawdemic", an educational game about the COVID-19 pandemic that teaches social distancing rules to young children. This digital artefact helped assess and validate the frameworks and methodologies applied during the design process. Likewise, as remote learning became the norm due to the COVID-19 pandemic, this project was purposefully executed remotely to further investigate the remote participatory design's feasibility. Lastly, the positive results and feedback of the game allowed the team to create four valuable groups of guidelines for future designers that seek to create similar experiences.

Keywords: interaction design, participatory design, learning experiences, rich experiences, instructional design, design methodology, backward design, COVID-19, computer sciences, prototyping.

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Kevin Solovjov Elio Brian Venero, Gothenburg, June 2021

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Introduction

The events of the year 2020 will be a matter of discussion for many years to come, and in many instances, it will be because of the wrong reasons. The COVID-19 pandemic has swept over the world, causing fear and erratic behaviour among the general population. News outlets provide a constant feed of graphs and statistical data, but the younger generations cannot fully understand the circumstances and implications. The psychological consequences of the pandemic in children are yet to be determined with the pass of time. But the likelihood of them struggling with a wide range of negative emotions, anxiety, and stress is latent. For instance, explaining the current world situation to young children presents itself as a wicked problem that reveals the complex challenges of tailoring and addressing a sensitive topic. For designers, this wicked problem raises questions like: how can a learning experience about a potentially frightening topic be delivered through an interactive digital artefact? What visual artefacts can be designed to improve understanding of viral infection like COVID-19 while minding the potential negative emotions? What methods can prove helpful when conducting research online with children?

In the wave of the COVID-19 pandemic, designers found themselves creating websites, software and apps to provide information and educate others on the subject more than ever before. Since online classes have gradually become the norm, the tools need to adapt quickly to an online format. Thus, to ensure the quality of the final experience, the design processes have to face even more challenges by shifting the design methods with a remote approach. Hence the increased importance of User Experience (UX) in education. Likewise, a field called Learning Experience Design (LXD) [5] aims to combine User Experience Design and the Instructional Design (ID) [6] to obtain better learning outcomes, although the work in this new area is still scarce.

This thesis project will try to understand and define the user experience's role within education; while also specifically studying the experience of learning in young children to see how designers could contribute to motivation, engagement, and information apprehension. In essence, through this thesis, the following main research question will be answered:

How suitable is the Rich Experiences framework to leverage negative emotions when introducing potentially frightening topics to young children?

A secondary research question, naturally derived from the execution of this project, reads:

What are some possible considerations when creating an engaging learning experience through an interactive digital artefact for children?

Consequently, these research questions will be contextualised and tackled within the design study of COVID-19 as a potentially frightening topic.
Initially, by using the existing findings in *Instructional Design (ID)*, *Learning Experience Design (LXD)*, as well as UX studies focusing on children [7] [8], it's expected to discover an adequate way to design educational and interactive visualizations for children. Especially in regards to potentially frightening topics.
Lastly, a concept for an interactive visual artefact will be designed. Such artefact will work as a vehicle to embody feedback from the target audience, children (ages 9-12). The approach for the design of the artefact will be exploratory, meaning that it will be developed according to the research findings and feedback, since it addresses a wicked problem. The digital artefact will be implemented in conjunction with the company i3tex following adequate ethical procedures.

Therefore, the project concludes by providing answers to the research questions through *Pawdemic*, the digital artefact, and the presentation of groups of guidelines and considerations for designers. These resulting guidelines seek to empower other professionals that wish to create similar experiences, being mindful of potentially frightening topics and learning experiences with children. The guidelines can be found in the four following categories: "engaging learning experiences", "emotional considerations", "participatory design with children online", and "improving the flow of the digital learning experience".

2
Background

To understand how this research is positioned within prior studies, and why the intended research question is relevant, the reader must have proper context. Beginning by laying out the situation concerning world events and previous research, this section should provide sufficient background to clarify the importance of the research question.

2.1 Children During a Pandemic

The COVID-19 pandemic has had a myriad of tragic consequences for people around the world, including loss of life, economic devastation and a decline in quality of life due to lack of socialization. Many are unable to keep working in these conditions, and more still need to adapt to continue. Among these are countless children that have had to move their learning online [9], while designers struggle to rely on their usual user-centred methods to make this experience work. In some instances, it is possible to look back on previous research, but what can a designer do when participatory design with a user group that's already difficult to work with becomes even more isolated?

Numerous studies revolve around the importance of participatory design, but few involve young participants. While there are some examples such as the Mission from Mars [10], many studies that do include children manifest their findings from a usability point of view [11]. Additional difficulties exist when considering children in such studies, including obtaining consent from guardians and the challenge of keeping them motivated enough to participate actively. These problems create a significantly higher barrier for conducting participatory design when compared to adult participants, which could have contributed to the scarce literature.

In a similar vein, most methods relating to participatory design are not designed to be conducted online, and neither are most of the related studies. This issue has become a large hindrance during the pandemic as social distancing laws and the risk of infection coerce designers to work remotely. There is useful research regarding remote participatory design, such as how to use social media in the process [12], or design tools for participatory design [13], as well as more theoretical frameworks and guidelines [14] [9]. However, the real problem is that the existing hurdles of involving children are further exacerbated by the fact that even fewer participatory design methods (like workshops) are suitable for remote work with children. Thus,

aside from the previously mentioned challenges when working with children, the remote design methods also need to consider the computer illiteracy among young participants and the lack of a physical presence to motivate children.

2.1.1 Wicked Problems

Wicked problems have complexity as one of their main features. If the space in which a wicked problem exists is defined, it will overlap with the solution space; meaning that both influence each other, and there is no definitive solution [15]. In such cases, Lindberg et al explain that scientific approaches that use inductive and deductive schemes are not suitable; since it's unlikely to come up with a single definitive solution. The authors also point out that design problems, like wicked problems, are blurry and not possible to define in their entirety [16].

Many of the issues faced in designing for children come from uncertainty about children's behaviour, their interactions with technology, their learning experiences, and their emotional maturity. While trying to define what the issue in designing for children is, one would already be on their way to solving it. Therefore, the present considerations appear to fit the mould of a wicked problem.

2.2 Learning Experiences Online

Design for education has been widely studied and codified within the field of Instructional Design. Instructional design, or ID, is described as a framework for systematically creating instructional products and experiences that can aid the effective acquisition of knowledge [17]. A good amount of research has been done within ID to create guidelines, frameworks and tips for various educational experiences that range from university courses to online tools and textbook design. Frequently, research like these focus on adult and young adult users but might not always apply to younger children.

Some strides have been made to remedy this missing knowledge, some include the study of theoretical topics like participatory design with children [18], as well as studies relating to the effectiveness of specific mediums and tools for learning [19][20]. Nevertheless, research involving children within ID is still scarce.

Simultaneously a growing branch of Instructional Design called Learning Experience Design (LXD) aims to combine User Experience Design with Instructional Design [6] to create educational experiences in a human-centred and goal-oriented way [5]. The philosophy guiding LXD is that creating learning experiences is an iterative creative process that does not fundamentally differ from conventional design processes within user experience design.

The LXD approach becomes more relevant as learning moves into online formats due to rapid digitization and critical factors such as the COVID-19 pandemic. Instructional design has become increasingly learner-centric and goal-oriented, which

has forced it into the user-engagement approach of UXD to become a broader field [21].

Learning experiences increasingly occupy the same mediums as the digital artefacts that many modern designers have spent years perfecting; such as websites, desktop applications and mobile apps. As entrepreneurs, companies and schools try to capitalize on this shift, designers now are tasked with creating learning experiences. This recent development has created an environment where experienced designers need to integrate the learnings of ID into their present methodological toolboxes and methods, naturally leading into the mindset that LXD-theory attempts to build upon [22].

Being an extension of ID, the field of LXD still faces the same issue when designing for children regarding scarce literature. This lack of previous knowledge has become glaringly obvious as the demand for online teaching tools for children has skyrocketed during the COVID-19 pandemic. Teachers express their frustration while trying to use existing tools and teaching methods for remote education with younger pupils [23].

2.3 Emotional Persuasion

The COVID-19 pandemic has demanded an unprecedented level of civic responsibility to prevent the spread of infection, at least in modern times. It has become necessary for everyone to do their part by committing to social distancing, wearing masks and observing various hygienic routines for the good of others and themselves. This responsibility also falls on younger children; which puts parents, schools and other organizations in the difficult position of educating them about a serious and potentially frightening topic.

Substantial research has been done on how to design for and around various emotions to deliver richer experiences [24]. Although similar studies involving children remain lacking, studying negative emotions and their ethical implications can be considered among the possible reasons behind this knowledge gap. Furthermore, it's also important to ponder the impact and challenges that emerge when prompting children to solve goal-directed tasks that will be evaluated. Thus, creating design guidelines for teaching children about things that are scary and uncomfortable can prove valuable.

On one hand, there's a clear discrepancy between understandings of how to design learning experiences for adults in contrast to children. On the other, there is scarce literature that tackles how to teach children about frightening topics. Thus, pointing out design guidelines based on the theory and best practices of instructional design, learning experience design, and the leverage of negative emotions, can become a valuable contribution to research and design communities.

3

Theory

This section presents the theoretical concepts and frameworks that surround the Master's Thesis study. These concepts are displayed in Figure 3.1 and will be tackled strategically in order to understand the wicked problem and theoretical underpinnings. The findings will help extract methods and techniques that can prove useful in finding potential solutions. For instance, a definition of User Experience will be followed by other fields it relates to and encompasses, such as Interaction Design, Participatory Design, Instructional Design, and Emotional Persuasion. In synthesis, the theory section frames those concepts and highlights the tools and methods that can prove useful.

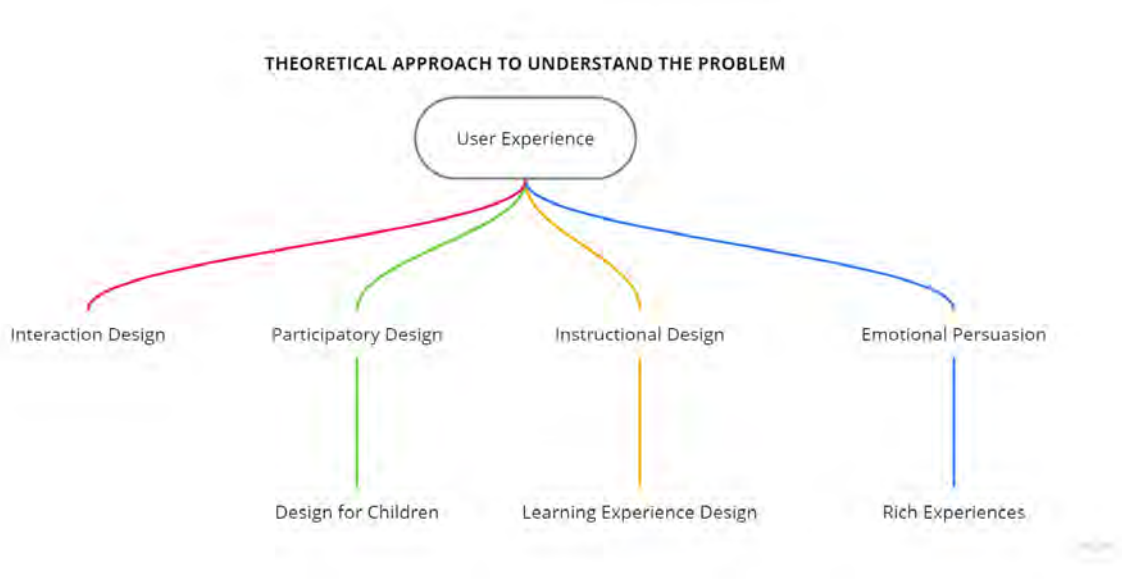

Figure 3.1: Theoretical Underpinnings in the Theory Section - Made in Miro [1]

3.1 User Experience

User Experience (UX) is the core foundation for the present research. Its definition may vary in many instances, in most cases due to diverse interests and backgrounds from authors [11]. ISO 9241-210 defines UX as the "user's perceptions and responses that result from the use and anticipated use of a system, product or service" [25]. UX takes the impact that a designed artefact can have within its target audience into consideration. It is worth noting that anticipation of use is part of the consid-

erations within the scope of a resulting user experience.

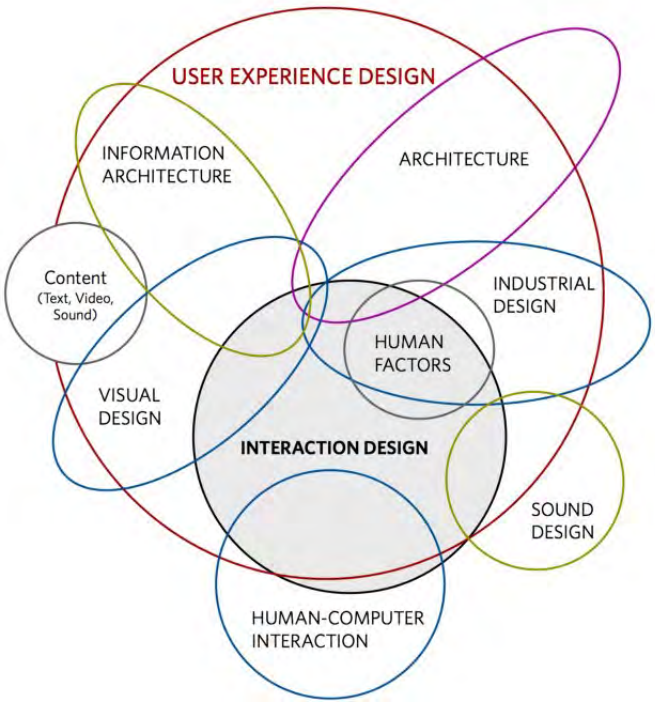

Figure 3.2: Interaction Design and User Experience Design[2]

In essence, UX can be considered equally as a phenomenon, as a field, and as a practice [26]. The main difference relies on the angle and approach designers take when defining and applying the concept. For instance, according to Roto et al [26], UX can be:

- A field of study. It researches into ways to develop certain experiences in users; as well as in the creation of new methods to design user experiences.
- A phenomenon. In which an individual gets a certain type of experience when encountering a system; whether it be a product, service or an artefact.
- A practice. Used as a design part in order to deliver the desired experiences to people, or evaluate the quality of the user experiences. It's often addressed as *User Experience Design (UXD)* due to the encouragement of practices from another field called *design thinking* [15].

Furthermore, because of that flexible nature, the user experience can easily overlap with other disciplines by lending its methods, practices, and approaches(Figure 3.2). This perception, however, can get clouded when learning about the fields like Interaction Design, as will be seeing further upfront.

3.1.1 Interaction Design

In order to design a product that provides a good overall experience, it's imperative to understand the implications of interactions. In many cases, they alone can determine whether the product delivers positive results (enjoyable experiences) or whether they derive into negative results that can cause frustration and annoyance [15].

Often the terms *User Experience Design (UXD)* and Interaction Design are used interchangeably. But in contrast to the previous introduction, arguably, the definition of interaction design [15] can be comparable to UX as a field of study [26]. Thus, both handle methods, approaches and theories that support design decisions, and both are key for the present study. Nevertheless, Sharp et al point out that *Interaction Design* means "designing interactive products to support the way people communicate and interact in their everyday and working lives" [15]. For instance, among the results after applying an interaction design process, an interactive product will provide its real-world users with a certain experience. Nonetheless, as also stated by Sharp et al [15], such user experiences can not be designed, as it is the product the one that can be designed "for" the desired user experience. In other words, the artefact is a designed mean to provide the user experience. certain

3.1.2 Participatory Design

In theory, so far, the emphases have been put on the product and the resulting experiences. While in practice, it's also a matter of understanding the users that are involved. This does not only mean understanding their needs but comprehending the users' cultural beliefs and other aspects that can potentially reveal incorrect assumptions about them. These considerations need to be present alongside evaluating the level of accessibility and inclusiveness of the resulting product [15].

When studying user experiences, the users' inputs and values are considered in many different ways. In the United States, there is a popular approach called the User-Centered Design (UCD), in which the user was considered a subject to be studied and understood. The Northern European participatory approach instead sees the users as partners in design [3]. Figure 3.3 displays a visual representation of both these approaches.

When it comes to user involvement, the application of *Participatory Design (PD)* practices can allow the users to be an essential part of the idea generation process and decision making [3]. Their participation and feedback in those key moments can ensure that real problems are the target throughout the design process [15].

Thus, by employing PD methods, the users play the role of "experts" of their experience [3]. Allowing the designers to understand their different points of view [15] through a mutual learning experience that usually comes in the shape of workshops. Therefore, designers, besides having the role of giving form to the ideas, also have to act as facilitators that lead and guide the users during the practice of the partic-

ipatory design methods [3].

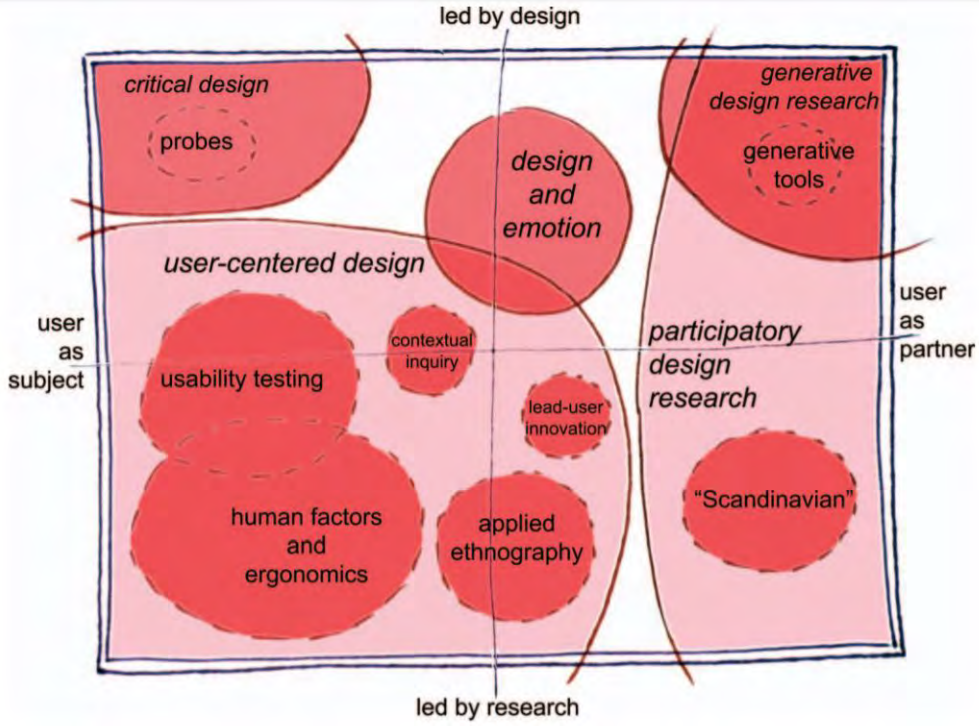

Figure 3.3: User-Centred Design as an Overarching Field on the Left Side and Participatory Design on the Right Side. [3]

3.1.2.1 Design for Children

When designing, a product that works for a determined users' type might not be appropriate for another. For instance, children display different attitudes when learning or playing than adults. They can be easily motivated by interactive puzzles, while adults might find the activity annoying or boring because of the lack of adequate stimulation [15]. Thus, it is relevant to tailor interactive products and new technology according to children-specific needs [10].

A relevant challenge when researching with children is that one can not simply ask them if they like a product or not, since children are known to be afraid of offending others [15]. This is the reason why many new methods for designing technology for children focus on making them participants of the design process [10] instead of only requesting their feedback to validate a product. Therefore, it is pertinent to use PD methods to involve children in the idea generation and decision-making processes [3].

3.1.3 Instructional Design

To design an educational experience requires theoretical and technical approaches that can be easily associated with the design of user experiences. *Instructional De-*

sign (ID) can provide further knowledge when it comes to the creation of valuable learning experiences. The *Learning Experience Design (LXD)* can contribute with convenient tools to fuse design processes and the development of learning experiences.
When it comes to design for understanding and education, Instructional Design (ID) is a field that can be traced back to 1950 [27] and provides models and frameworks that can help understand and systematize the design of learning processes [28]. Consequently, ID gives designers many tools to develop a clear understanding of the learning "destination" of the users; and how the instructions serve as "paths" that facilitate the achievement of those learning goals [29]. Among those frameworks, *understanding by design* sees teachers as designers that craft learning experiences to meet specified purposes[30]. Likewise, it proposes a *backward design* process in which the desired results are identified first, then how those results would need to be assessed, and lastly, the learning experience is planned out. Although counter-intuitive, this approach aims to be a very systematic way to deliver learning goals.

3.1.3.1 Learning Experience Design

Applying the *Learning Experience Design (LXD)* methodology, according to Floor [5], sets "activities that enable the learner to actually reach specific goals". Thus, said activities are comparable to the instructions provided by instructional design. Moreover, both design approaches are goal-oriented; both focus heavily on the theory of learning and can also be user-centred (or learner-centred) in many instances. Thus, there are scenarios in which both terms are interchangeable.

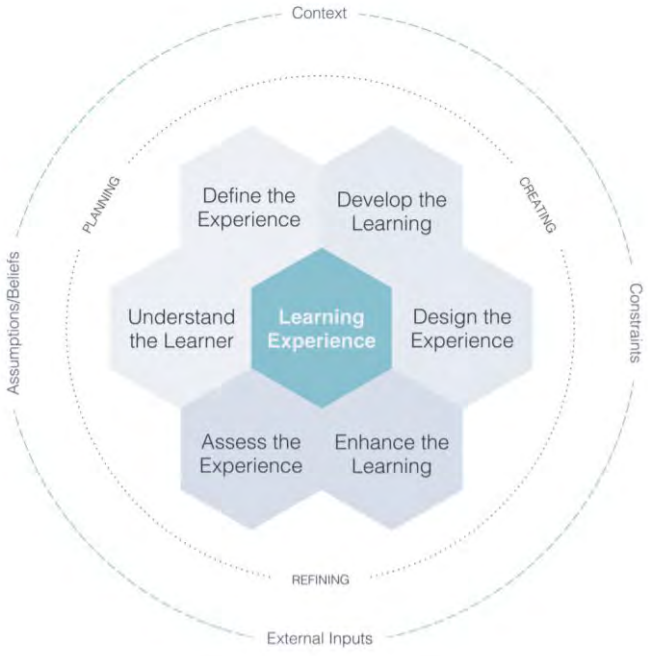

Figure 3.4: Steps From the Learning Experience Design Framework

Nevertheless, as some authors point out [27][31][32], an essential difference between LXD and ID seems to rely on the approach to the learners and the focus in the learning experience itself, not only in the provided instructions. Arguably, it can be said that ID tackles how people learn and how to systematically achieve a learning goal, while LXD analyses the learner's experience by viewing it through 'user experience design' lenses.

A recently proposed framework for Learning Experience Design considers a set of six design steps: understand the learner, define the experience, develop the learning, design the experience, enhance the learning and assess the experience; as can be seen in Figure 3.4 [32].
Moreover, while presenting their arguments about learning experience design framework, the author also remarks on the design thinking (DT) approach. Frequently, *Design thinking* has been defined as "an approach to a problem-solving and innovative design that focuses on understanding what people want and what technology can deliver" [15]. To do that, DT proposes practices that can evolve a product into a suitable solution. In consequence, this is what the author implies when stating that the LXD framework uses core concepts from DT, like its iterative nature and the focus on solving the right problems [32].

3.1.4 Design for Emotional Persuasion

Emotional design is an area that has been growing quite a lot in recent years in consideration of the impact that technology has on people. Nowadays, it's not uncommon to find apps that enable people to reflect upon their emotions or feelings [15]. Some other products make people emotionally attached to them, and those are just some examples [15]. In general, eliciting emotional responses from the users might happen without planning for them. Because of human nature, emotional responses are displayed when interacting with the environment and experiencing something particularly frustrating for some users but simple for others. Hence, the implications of designing good experiences through the use of deliberate emotional expressions or persuasions [15] are an ongoing challenge. For instance, a mindful solution that considers its emotional impact can use tools that focus on leveraging negative emotions, such as the *Rich Experiences framework*.

3.1.4.1 Rich Experiences

The *Rich Experiences* framework seeks to demonstrate how the involvement of negative emotions can enrich the user experiences [24]. According to Fokkinga and Desmet, the framework successfully presents how and under what circumstances negative emotions open the path to the origination of emotionally rich experiences. The rich experiences framework consists of 3 steps:

First, selecting adequate negative emotions according to the users' context. A designer can look for an existing negative emotion and how that emotion can contribute to a rich experience or investigate what a rich experience can contribute

to an otherwise ordinary activity to make it notable. Fokkinga and Desmet provide an example of adding an element of fright to a waiting room to make it more lively and exciting, an emotion that is not usually associated with waiting rooms[24].

Second, how and when the negative emotions need elicitation. Here the designer can again choose an existing emotion intrinsic to the interaction or context or create specific scenarios where the experience evokes certain negative emotions through interaction or related behavior.

And third, selection of a protective frame that needs to be adapted to the product concept to allow and achieve emotion reversal [24]. The protective frames are mental constructs that allow the negative emotions to exist without overwhelming the experience. Fokkinga and Desmet bring up the example of a caged lion, where the user can fear the lion but still enjoy watching it because they know that they aren't in danger thanks to the cage. In this case, the cage is a protective frame. There exist different kinds of protective frames described in the framework which are suitable for various negative emotions. The cage that makes a lion exhibit enjoyable would not necessarily work for an emotion like frustration.

3.2 Children and Difficult Subjects

Speaking to children about difficult subjects is very different compared to discussing the same things with an adult. When conversing with a child, one has to be mindful of the language used and which information to convey. A great deal of research has gone into how to best approach this dilemma within the field of psychology. *New York University Child Study Center* provides guidelines for communicating difficult subjects to children which can be summarized as follows [33]:

- Be extra aware of their emotions
- Be aware of your own emotional state
- Find out how your child is feeling by inviting open-ended conversation
- Find out what your child has seen or heard
- Be sympathetic and non-judgmental about children's reactions and feelings
- Don't provide unnecessary details
- Don't avoid the subject
- Be mindful if a family member or friend is seriously ill
- Be honest
- Be reassuring
- When talking about death, avoid euphemisms
- Be aware of time and place
- Don't minimize your child's fears

The team will keep these guidelines in mind when designing the experience and developing new design guidelines to answer the research question.

4

Methodology

This section presents the methodological approaches, working, at the same time as a toolbox that collects different methods to be executed throughout the Master's Thesis project. Figure 4.1 displays a visual representation of the Methodology section where the research approaches will be tackled first. Later, the design process methodologies are described, and lastly, the design phases and the methods involved. The design phases place the methods following an iterative approach. Thus, an iteration that ended in a convergent phase can go back to previous divergent design phases to explore the solution or problem spaces better.

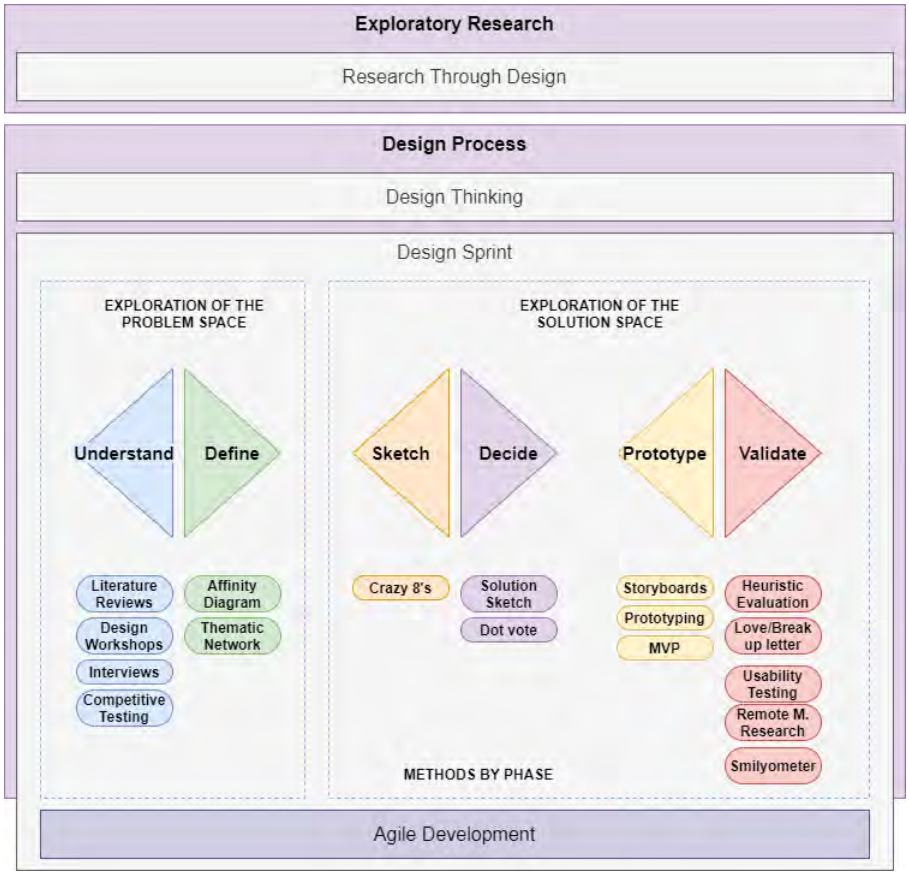

Figure 4.1: Visual representation of the Methodology Section and the Design Sprint

4.1 Exploratory Research

User studies and product studies characterize the *Exploratory research*, seeking to create groundwork knowledge that can help designers thrive in unfamiliar territory. Moreover, exploratory research is flexible and encourages finding inspirational sources rather than concrete data for formal analysis. Ideally, an *exploratory research* translates to a good understanding of the target audience and the research context, as well as a tangible design outcome or guiding criteria for future studies [34].

4.2 Research Through Design

Within the design field, to research with the sole purpose of gathering information to address a complex problem [35] is not enough. For instance, by using a *Research Through Design (RtD)* approach, it is expected to use a variety of methods and frameworks that will finally lead to a tangible solution [36]. RtD links theory and newly gathered knowledge [34] together with practice [37] to come up with an ideal solution. In other words, as Herriot concludes, RtD implies making observations about the world, coming up with a hypothesis in which the user needs a particular artefact, and then validate the hypothesis by designing a prototype of said artefact [37].

Providing viable solutions to wicked problems requires the use of an approach that can contrast with the analytical thinking in science; such is the case of the strategies called 'design thinking' [16]. Lindberg et al explain that these strategies provide solutions pragmatically and within short time frames; and where the agents that are part of the problem highly influence the viability of the solution [16].

4.3 Design Process

The iterative design process will follow two approaches to explore solutions that can address the research problem:

4.3.1 Design Thinking

Some authors consider design thinking as a mindset in which "the product concept and design for emotional impact and the user experience are dominant" [38]. Others define it as an "approach to problem-solving and innovative design that focuses on understanding what people want and what technology can deliver" [15]. Nevertheless, regardless of which definition can be the most adequate, its focus on people and experiences is beyond question. Moreover, design thinking presents a unique contrast with scientific problem-solving approaches due to its pragmatism; and the consideration of problems and the solutions as things to be explored[16]. In this sense, Lindberg et al [16] highlight three characteristics about design thinking (Figure 4.2):

First, the exploration of the problem space achieves intuitive understanding through observation. The exploration of the solution space demands several ideas tangibly represented with sketching and prototyping techniques.
Second, the iterative alignment of problem and solution spaces facilitates communication with the agents involved in the problem. Which, in turn, keeps a good sense of perception of the viability of the possible solutions. Ultimately, this will ensure a suitable and innovative solution that addresses the complex problem[16].
Third, the process of design thinking must show an interplay between diverging and converging mindsets [16]. Diverging implies exploring the problem and the possible solutions, whereas converging requires designers to synthesize, narrow down scopes and select what paths to take.

Figure 4.2, resembling a double diamond, is a visual representation of the three characteristics and the divergent/convergent approach. On a similar note, the double diamond framework[39] is very traditional in Interaction Design[15] because it displays the divergent/convergent mindsets and an iterative approach very similarly. Nevertheless, it's the design thinking approach that also serves as the foundation for frameworks like LXD [32].

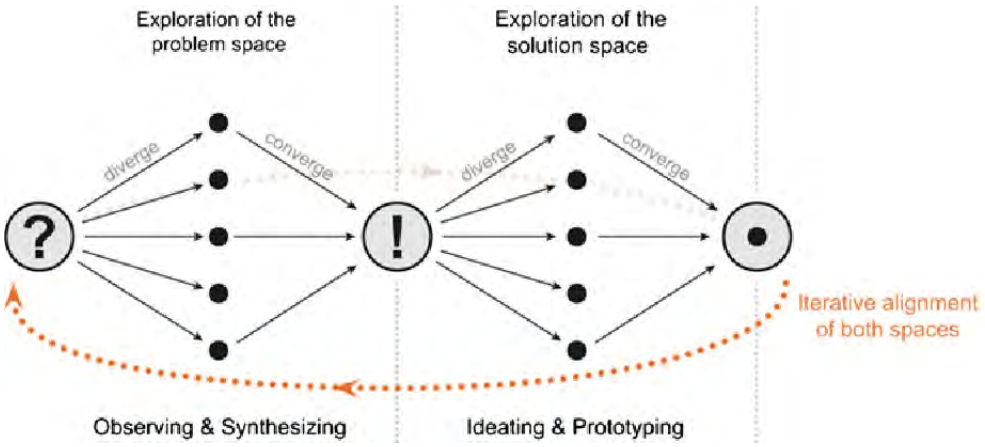

Figure 4.2: Design Thinking Approach

4.3.2 Design Sprint

The Design Sprint is a "methodology for answering critical business questions rapidly through [d]esigning, prototyping, and testing ideas with users" [40]. This methodology follows the iterative divergent/convergent [16] approaches as well as design phases based on the design thinking process [41]. The six design phases for the Design Sprint are: understand, define, sketch, decide, prototype, and validate (Figure 4.3).

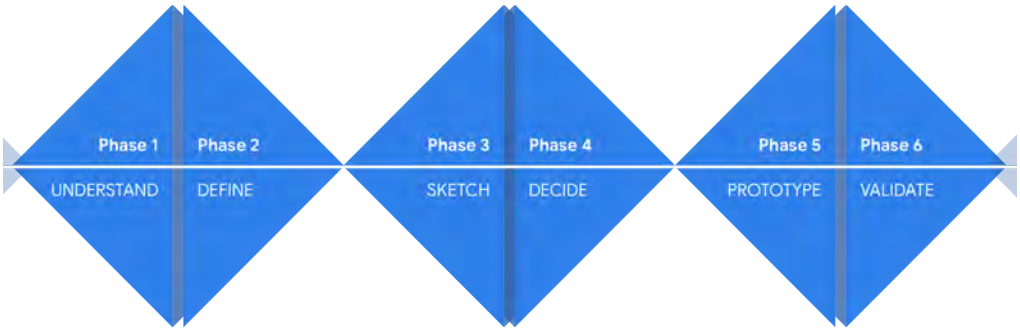

Figure 4.3: Design Spring by Google [4]

The following section describes the different design methods to be used in each one of the design phases. Each design method falls into an overarching exploration field, either the problem space or the solution space.

4.3.3 Backward Design

The *backward design* is a curriculum development model with three different stages. It starts with 'Stage 1' by defining the desired learning outcomes and framing them as questions. 'Stage 2' requires the designers to determine the assessment methods to collect evidence of the desired learning outcomes. 'Stage 3' determines the activities to be done to deliver the understanding. Lastly, the author presents this model as a flexible tool that can adjust to the designers' needs, purposes, and interests [30].

4.3.4 Methods for Exploration of the Problem Space

4.3.4.1 Understanding

With a divergent mindset, the understanding phase of the design sprint aims to create shared knowledge [4] across the people involved in the design process. The methods considered here are:

- **Literature Reviews**
  Literature reviews are used to "distil information from published sources" [34] to learn about previous projects and understand the context. Moreover, they are valuable in design projects when it comes to synthesizing research on a specific topic without losing sight of the connections between references that could be relevant to the project [34]. Thus, literature reviews include books, journals and magazine articles, theses, websites, blogs, and other documented projects.

- **Interviews**
  Interviews are a fundamental research method to gather knowledge directly from the users or stakeholders [34]. Whether interviews have a very well

structured script to carry out with the users, or if they allow the flexibility of a conversation[34]; interviews need adequate guidance towards the knowledge that the designers seek: such as personal experiences, attitudes, opinions, and others.

- **Design Workshops**
  Design workshops are a form of participatory design that integrates participants into the creative process by working side by side with the design team[34]. Martin and Hanington explain that workshops consist of a set of activities conducted by the design team and facilitators [34] to assist the design processes and gather knowledge. Due to the circumstances surrounding the Master's thesis, the workshops need to be tailored, not only in terms of the target audience but due to the need for an online participatory design approach. In consequence, the design conversation will take place employing an online tool [9].

- **Competitive Testing**
  Competitive testing assesses and evaluates different characteristics of the competitors' products by playing the role of an end-user [34]. The method consists of taking note, identifying, tracking and analyzing the similarities with the competitors. Although it's also important to note key features that are not so similar, or not desired to be, since they will ultimately lead to market differentiation [34].

4.3.4.2 Defining

Define phase intents to establish a reasonable focus. Specifying context or defining the desired outcomes of the potential solutions [4] are a way to converge the ideas. The methods in this phase include:

- **Affinity Diagram**
  Affinity diagramming clusters observations that can lead into insights about the research [34]. Martin and Hanington also point out that this method is carried out by writing observations, requirements, opinions, or relevant gathered data into individual sticky notes. Then, the sticky notes are clustered affinity-wise, which can easily leverage new insights within the themes of the research that were previously dismissed [34].

- **Thematic Network**
  A thematic network is a process that helps the designers identify, organize and connect implicit themes within rich quantitative data [34].
  Martin and Hanington also explain that the method consists of breaking down long texts systematically into clusters of themes that can let the designers explore relationships between the information visually. With this purpose in mind, there are three types of themes to consider: "basic", "organizing", and "global" themes. "Basic" themes are only meaningful when combined with others, whereas "organizing" themes are composed of many "basic" themes

with similar issues. Lastly, the "global" themes work as a summary; they are abstract and overarching themes [34]. After finding the themes, they need to be reviewed and named accordingly [42].

- **MoSCoW** The MoSCoW method is a helpful prioritization technique to concentrate efforts on the most valuable parts of a project. It requires the consideration of what requirements must be, should be, could be, and won't be part of the solution [43].
  "Must have" requirements can determine the failure or success of the project. Meanwhile, "should have" requirements, although they are not necessary for the project to work, they are desired. Similarly, "could have" requirements are desired but can only be considered given a case where there are enough resources for them. Lastly, "won't have" requirements are left out because they are not going to happen, and they won't be considered in the future [43].

4.3.5 Methods for Exploration of the Solution Space

4.3.5.1 Sketching

The sketch phase intends to diverge into a broad range of ideas for solutions. Designers need to gather inspiration from alternative solution spaces and individually come up with ideas to be considered [4]. The methods in this phase include:

- **Crazy 8's**
  The crazy 8's is a fast sketching method that, in essence, requires the participants to sketch eight different ideas within eight minutes [44]. It's worth noting that although the task might seem challenging, the sketches don't need to be artistic but only manage to communicate ideas, no matter how impossible or impractical, since they can serve as inspiration for further innovation [44].

- **Solution Sketch**
  Within the Design Sprint methodology, Solution sketches [45] are meant to be created by each one of the team's members. This method consists of using outcomes from previous design methods, like Crazy 8's, and other people's ideas to create a concept that is developed enough to be considered a fully fleshed solution.

It's worth noting that this phase will be highly influenced by the *rich experiences* framework [24] and the understanding by design process [30].

4.3.5.2 Deciding

Decide phase converges into a finalized concept to be prototyped. The methods here get consensus over the prototype by using decision-making exercises [4], among them:

- **Present Solution Sketch**
  Each participant should name their Solution Sketch concept and present it

with three additional frames that visually display its functionalities for a maximum of five minutes [46].

- **Mood Boards**
  A mood board [34] is a set of collected illustrations and imagery that can visually communicate ideas and concepts. This collage of pictures serves as a design intent description, aesthetic feeling, style, or similar. These boards result after the team has decided and set a general design direction to follow and when they want to maintain it throughout the design process.

4.3.5.3 Prototyping

The prototype phase focuses on designing an artefact that is real enough to be used as a validation tool of the hypothesis when encountering potential users. The prototype itself doesn't require a functional back-end but must have been thought critically enough to get feedback that either validates or invalidates the concept [4]. The following methods follow this purpose:

- **Storyboards**
  Martin and Hanington explain that storyboarding is a valuable method for the early phases of the design process because it delivers a rich visual narrative of how the product will be used. Moreover, the authors also highlight how, regardless of only being stick-figures, storyboards manage to successfully communicate relevant social, environmental, and technical factors of the product's context. This rich narrative builds empathy on the users, which subsequently can make their inputs much more valuable [34].

- **Prototyping**
  Prototyping is defined as "the creation of artefacts at various levels of resolution, for development and testing of ideas [...] with clients and users"[34]. In regards to high-fidelity prototypes, and contrasting low-fidelity prototypes like a storyboard, Martin and Hanington explain that they are refined and often look and feel like the final product, implying that they can also present interactive capabilities. This high-fidelity prototypes provide a real user experience when being evaluated by the users, which ultimately entails better feedback in terms of usability, form, aesthetics and interactions [34].

- **Minimum Viable Product**
  A *Minimum Viable Product (MVP)*, for a product or solution, is a set of features that are functional and that are deployable. In essence, in contrast to a high-fidelity prototype, it should deliver value to the user while also getting valuable feedback in return that can lead to future improvements and iterations [47].

4.3.5.4 Validating

The validation phase mainly focuses on gathering the feedback that can precisely validate or invalidate the concept for a solution [4]. Since the main objective of this phase if gathering inputs that make the design concept progress; there is a large variety of methods to contemplate, either with the specific target audience or even with experts and stakeholders:

- **Heuristic Evaluation**
  Also described as informal usability evaluation, this method gathers experts to assess an interface and provide feedback based on best practices for usability. For instance, this method is ideal when prototypes require an inspection that can address baseline usability problems before evaluations with real users begin [34].

- **Love Letter and Break Up Letter**
  Based on the premise that a personal letter reveals profound insights about how people feel, these two methods allow the participants to express their emotions, not about a person, but an experience with a product. The results are expected to be deep and reveal an intricate relationship that could lead up to interesting insights [34].

- **Usability Testing with Think-aloud Protocol**
  Martin and Hanington explain that this method "focuses on people and their tasks, and seeks empirical evidence about how to improve the usability of an interface" [34]. The evaluators have the chance to observe and take note of how the user responds to the tasks at hand, such as reactions, time, level of completion of the tasks, and others. The authors also mention that this method usually follows the think-aloud protocol to understand the user's thought-process and listen to their contextual suggestions for improvement of the digital application [34].

- **Remote Moderated Research**
  In contrast to a typical Usability Testing scenario, the Remote Moderated Research [34] takes the evaluations from a lab to an online format. For instance, when evaluating, each participant will share their screen with the researchers for them to carry on with the Usability Testing[34]. The researchers can complement this evaluation by asking follow-up questions to the participants.

- **Smileyometer**
  The Smileyometer is a scale specifically designed for children to measure fun and enjoyment. When it comes to scales, Sluis et al explain that children tend to provide extreme answers. Moreover, children can display the experimenter effect, in which they react and guess the evaluators' expectations. Because of that, they proposed a new type of scale, called the Smileyometer. This scale uses smileys to depict the options with a better empathetic approach. Thus, according to their results, this new scale is reliable to gather more fine-grained

answers when used with older children (10-12) [48].

4.4 Agile Development

In order to fit in with the iterative design process chosen for the project the software development must also follow an iterative and flexible process. For this reason, the code-writing parts of the prototyping will follow the Agile Development process. Agile Development is a broad term for a software development philosophy which promotes iterative deliveries, early results and pivoting during development [49]. Compared to traditional software development frameworks like the Waterfall method, where software is developed in one single long process from idea to product, Agile uses short code sprints following the same philosophe as the planned design sprints and offers much more flexibility during development which will be important as the design evolves because of research and feedback. Each iteration of an agile sprint will follow the design sprint from understanding to validating by running in parallel with the same end dates for the sprints.

4.4.1 Jira

Jira [50] is a popular software development tool that helps organize agile processes. Specifically, it helps with tracking tasks of various sizes and allows tasks to be organized according to sprints. Jira will be used in this project to track both software development but also design tasks, unifying both the agile and the design sprint into a single process. The software allows for both Scrum and Kanban approaches to agile, but the team will use it's implementation of stricter sprints to follow the Scrum approach of the partner company for the project.

Jira will give the team as well as supervisors a good overview over what is being done during development, completed tasks and what is currently being planned. It will serve to track process, goals and keeping track of who is responsible for every listed task [51].

5
Execution and Process

5.1 Planning the Project

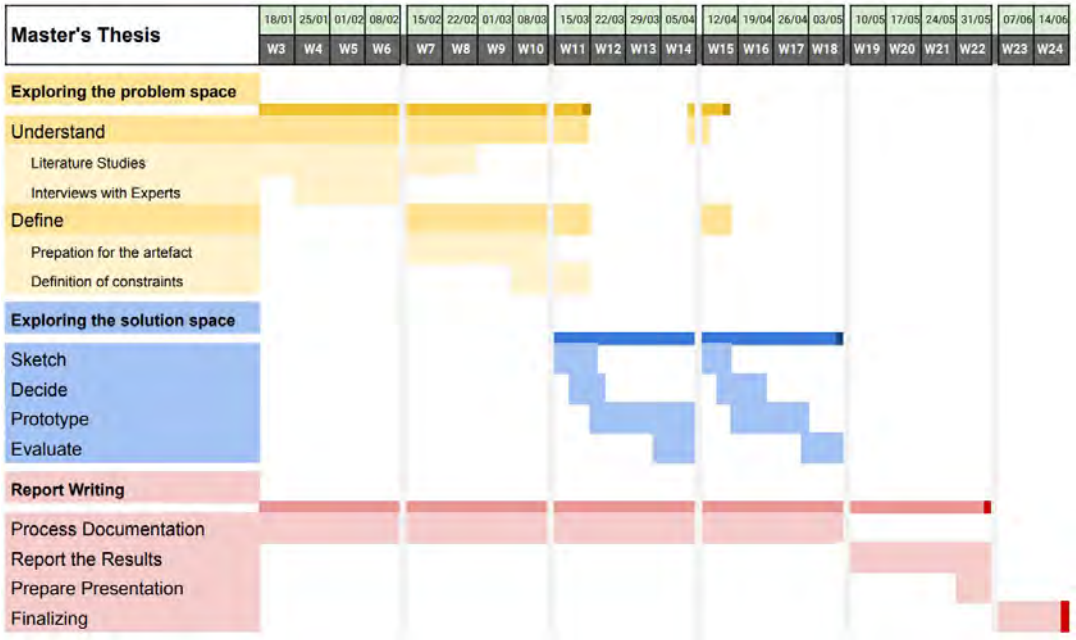

Figure 5.1: Gantt Diagram - Master's Thesis Plan

The plan for the execution of the Thesis project can be seen in Figure 5.1. The project will follow a phase of exploring the problem space, followed by the exploration of the solution space. The Google Design Sprint Methodology will serve as a general guideline, and the work will be divided into the six design phases as described in the methodology. This process is expected to have multiple iterations within the design sprint, alongside smaller iterations of certain phases, depending on feedback and the need for further research.

The phases of the Google design sprint can be somewhat analogous to the phases of an LXD Process (Figure 3.4), hence the team will attempt to blend Instructional Design processes when and where appropriate. For example, while understanding the users' needs from a design standpoint, additional care could be taken to understand them as "learners". The emphasis will also be set when designing and assessing the learning experiences.

Defining and developing the learning experience will be an integral part of creating the broader user experience. Validating and evaluating the prototype will help assess the learning experiences, and ultimately gather improvements for the artefact. This will enhance the learning experience as the main goal. Therefore, the entire design sprint will be seen through an LXD lens.

5.1.1 Planning: Exploring the Problem Space

The first two phases of the Google design sprint have been adapted to work with the initial phase of exploring the problem space. This phase will focus on understanding users, doing research, and setting up a theoretical base for more practical work.

5.1.1.1 Understanding

At first, the understanding phase will consist of reading and reviewing scholarly sources to collect a toolbox of methods that might be an aid in tackling the stated wicked problem. Initially, competitive testing will gauge the success and quality of existing visualizations. Later, interviews with experts will collect information on how to tackle the upcoming challenges; including gathering methods and general tips of designing for children and creating visualizations. Finally, a workshop will be conducted with a small group of children to understand the target group better.

Qualitative methods like interviews and workshops with users have been chosen instead of quantitative data since qualified experts and young children are hard to come by as participants to get meaningful results from quantitative methods. Children must need permission from parents or collaboration with schools and other organizations. On the other hand, getting in touch with a significant number of experts would require collaboration with a faculty or company working in a related field.

When it comes to the children, the planned design methods will be used to understand the current level of knowledge and perception they have, specifically regarding the spread and prevention of viral infections. Participatory methods like the "KidReporter" workshop can provide relevant insights regarding what children understand from various visualizations, and learning what appropriate mediums to use to convey information to them.

- **Workshop**
  The workshop will be designed based on the "Mission from Mars" method [10]. The method will be adapted into an online format, but will otherwise remain unchanged. To ensure the best possible results, an interview will be held with the expert who co-designed the method to hear thoughts on how to adapt it. The workshop will also be tested with Interaction Design students at Chalmers University of Technology before facilitating it to children, so potential flaws and expert feedback can improve the experience.

  The core idea of the *Mission from Mars* method is to provide the children

with a character with whom they feel comfortable sharing their thoughts. The character is meant to be believably clueless about most things (hence an alien) so that it can ask basic questions that might seem stupid or condescending if asked by an adult. In this version of the workshop, the martian will want to know about what is happening on earth, especially regarding the COVID-19 pandemic. It will ask questions such as what a pandemic is, how it can be stopped and how it has affected the children. The answers to the alien's questions will provide insights into what the users already know about the spread of viral infections.

First, the parents or teachers of the children will be provided with an introductory session together with a confidentiality agreement describing the whole process and the reasoning behind the project. Afterwards, interviews [34] will gather their thoughts on the technology they think is better suited for their children to learn as well as their opinion regarding viral infections and the ongoing pandemic.

Brief interviews will follow the Mission from Mars workshop to get comments and more detailed descriptions of their perceptions on the matter. This qualitative information will serve as input for the design process.

5.1.1.2 Defining

Once the workshop is complete and results have been gathered, the results will need to be analyzed to define a direction for the project. A way to make sense of them is to look at compiled data, mostly transcripts and recordings of workshops, and identify common themes in the knowledge and experiences of the target group.

To accomplish this, the data will undergo a thematic analysis. Transcripts of the workshops will be coded by different categories which should improve understanding of common themes. This method will provide insights into the user's thinking by providing keywords and topics that the users often bring up. These keywords and topics can then become the focus of the visualization, or inform what the user's don't necessarily need to learn further.

To further categorize and understand possible focus points, an affinity diagram will be constructed in conjunction with the thematic analysis. Reading and coding the qualitative data for the thematic analysis will then also act as a preparatory exercise for the affinity diagram and aid in categorizing the results. Once done, the next phase can begin, where the possible foci will act as candidate topics to ideate.

5.1.2 Planning: Exploring the Solution Space

The remaining parts of the google design sprint serve as a basis for the second phase of exploring the solution space. This phase will focus on developing guidelines and formalizing findings through the creation and evaluation of a prototype.

5.1.2.1 Sketching

Once the common themes have been identified, the next step is to come up with a design solution. So the original of focusing on emotions is not lost in track, the entire ideation phase will be guided by the rich experiences framework and the findings from the understanding phase. This means that any methods used and designs proposed will need to take into account what emotions they deal with and what protective frames they include to make the user feel safe and comfortable.

The main method to form the basis of how the ideation is executed will be the Crazy 8's [44]. This method allows quick sketching of multiple ideas, resulting in possible ideas for features, helping to settle on concrete concepts. These sixteen ideas will be further reduced to three through sharing and discussions within the design team until the team feels prepared to choose one in the next phase.

5.1.2.2 Deciding

The deciding phase will serve to help the team pick out one idea that will be developed and evaluated. The array of ideas from previous phases, and the discussion about them, should give the team a solid understanding of what could be done. The team will make solution sketches incorporating the best aspects of the presented ideas to narrow down the focus. This process can be made even more valuable by including external experts to join in the sketching and presenting new solutions that the team might not have considered.

After one of the solution sketches has been chosen, it will be time to illustrate a golden path through a visualization. This method [52] will help move the design from a series of ideas into a concrete user path which will highlight every important step of the way and help identify which parts need to be prototyped. In this way, it will act as a bridge between the idea and a basic prototype.

5.1.2.3 Prototyping

Once an idea has been chosen, a prototype will be developed so that it can be evaluated with users. The first step of this will be to create a storyboard [34]. The storyboard will help illustrate key moments in the interaction and aid in deciding what aspects must be prototyped for testing. Furthermore, storyboarding helps unify the design teams' vision of the product.

While the storyboard can help communicate the key aspects of the design, a low fidelity prototype will not be sufficient to illustrate a visualization that relies heavily on interactions and visual cues. To remedy this, a high-fidelity prototype will be developed with code. A programmed prototype will behave much more like the final product while still allowing certain aspects to be "faked" if necessary by using a "wizard of oz" methodology [53]. Besides the apparent realism, an important advantage of prototyping with code is that the prototype can serve as a head-start for software development and act as a basis for a real application.

5.1.2.4 Validating

Validation of the design hypothesis is important to assure that the quality of the design is sufficient. Because of that, the validation will be extensive and will involve both users and external experts throughout the use of multiple evaluation methods. The validation phase will also be repeated until the design team is content with the feedback and fits the time constraints.

Validation will be held both with users and with experts, including differing methods for the two groups. The first method involving design experts is a heuristic evaluation [34]. The involvement of a handful of external experts will help avoid thinking in a bubble and will aid in finding inadequacies in the design. This method will help in identifying the most glaring problems with the design.
Once the heuristic evaluation is complete, a more in-depth method can find further improvements. The love letter break-up letter [34] method can complement the objective feedback from the heuristic evaluation, helping to gather more subjective opinions from the experts. Since the same experts will have gotten familiar with the visualization from the previous method, they will acquire a good understanding of their relationship with the artefact to either "break up" with it or send a love letter with motivations as to why they feel the way they do.

Depending on the expert's available time and involvement, interviews may be held to complement the information from the method. These will be prepared ahead of time in case it becomes relevant. The point of these interviews would be to ask specific questions about the design and experience that might be omitted from the previous method.

As for involving children, the evaluation session of the last iteration of the prototype will also include a usability test, requesting the children to think aloud when interacting with the artefact. Any problems when interacting with the prototype will be considered possible future improvements. There might be a limited set of participants due to the current circumstances, but the team will try to involve as many as possible.

Once the usability test is finished, it will be followed by a tailored smileyometer[48] to receive additional feedback of their experience and how they feel about viral infections after interacting with the artefact. Furthermore, by the end of the project, it is expected to gather enough feedback to comment on the relevance and impact of the different design and research methods.

5.2 Executing of the Project

This chapter will detail the execution of the research project in order to address the research questions. Particularly, some processes and methods differ from the previous planning due to a difference in scope and understanding from the teams' initial assessment and the exploratory approach while executing the project.

Nonetheless, the execution of the Design Thinking approach is shown by exploring of both, the problem space and the solution space (Figure 5.2).

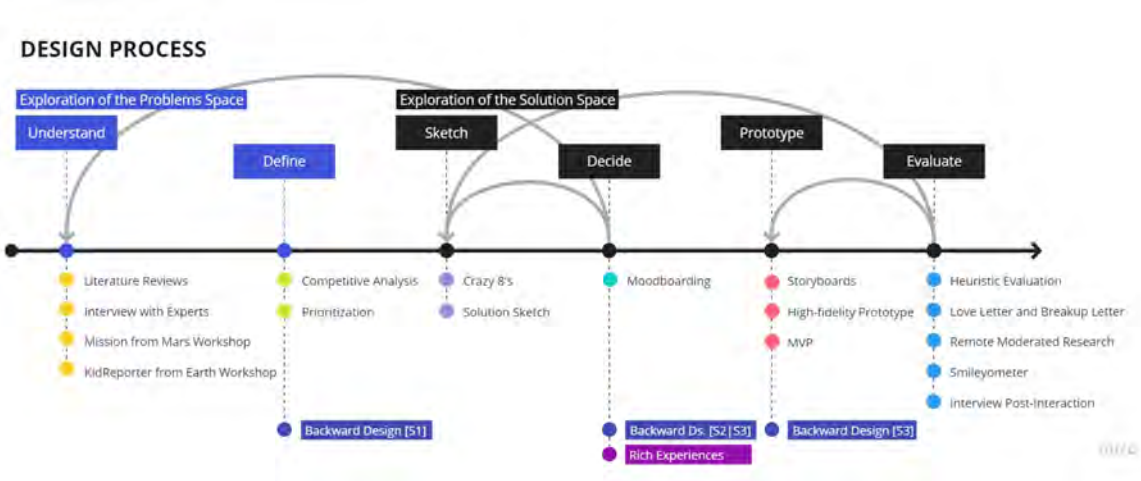

Figure 5.2: Design Process of the Digital Artefact

The process has largely followed the intended structure of the Google Design Sprint, while some specific methods were changed, discarded, or complemented with other research. A recurring problem faced by the team was the difficulty conducting user testing in the wake of the COVID-19 pandemic, and expert feedback was further emphasized to fill in the gaps.

5.3 Exploration of the Problem Space

The exploration of the problem space intended to achieve a better intuitive understanding of the problem at hand. In order to do this, a variety of design research methods were used, always following the phases in the Design Sprint.

5.3.1 Understanding the problem

The understand phase aimed to create valuable shared knowledge in regards to learning experiences, design for children, and emotional persuasion. Four methods where carried out to build enough knowledge to support the whole design process: Literature reviews, Interviews with experts, the *Mission from Mars* workshop, and the

KidReporter from Earth workshop. The outcomes from each one of the workshops will be described below:

5.3.1.1 Literature Reviews

The literature reviews included studying frameworks like LXD and ID. Finding interesting concepts and theories that lead to the considerations of *backward design* and the understanding of a *learning experience design* process. Likewise, literature reviews on participatory design with children provided useful tools for the creation of remote participatory workshops, such as the *mission from mars* [10] and the *KidReporter*[54]. The literature review in emotional persuasion led to a better understanding of the complexity behind emotions and the potential usefulness of frameworks like the *rich experiences*. Overall, the literature studies also facilitated the general perception and interconnections between the different topics.

5.3.1.2 Interviews with Experts

Expert interviews were carried out online through Zoom. The structure allowed fluid and flexible conversation while also addressing matters that the team found lacking knowledge and perspective of, such as:

- Consideration of General Data Privacy Regulation (GDPR) and consent forms when working with children.
- Age groups to work with, their characteristics and requirements.
- Comments in regards to frameworks like *research through design* and *learning experience design*.
- Guidelines or comments about participatory design methods with children.

Three participants, knowledgeable in product design and participatory design with children by profession or experience, were invited to the expert interviews. Each interview lasted around 45 minutes. They provided a better understanding of the context and limitations that the research needed.

The experts' comments were categorized into insights, things to do, and new sources to read. Among the most relevant inputs were: the importance of selecting an age group that could read (9-12 years old), having pairs of children as participants of the workshops to avoid shyness, optimally looking forward to work with the same group of children throughout the studies, and learning about their teachers' and psychologists' perspectives. Likewise, the outcomes included the addition of sources for consent forms, participatory design methods, and child-computer interaction.

5.3.1.3 Workshops

The participatory workshops involved children of the previously defined target group (9-12 years old). The goal of the workshops was to understand children's perspectives and knowledge about the COVID-19 pandemic by using a child-friendly approach. Nevertheless, due to the ongoing circumstances, the team chose to creatively adapt and organize all the workshops for an online format (Figure). This format also opened up the possibility of gathering inputs from children from different countries, considering the variety of measures that each country has taken amidst the pandemic.

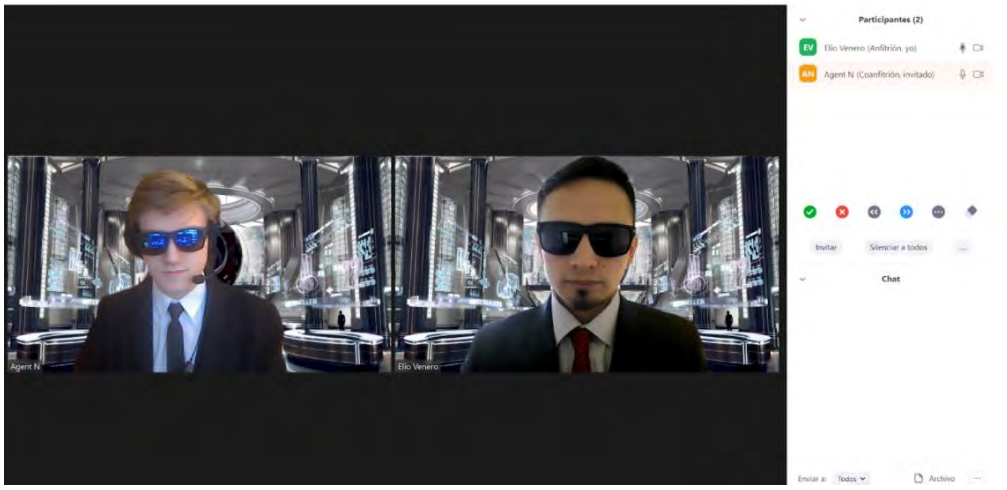

Figure 5.3: The Team Acting as "Men in Black" Agents for the Participatory Workshops

The *Mission from Mars* online workshop was heavily inspired by the participatory workshop, with the same name [10]. Ideally, the team planned to have the same pairs of participants across the whole study, as suggested by the experts. Thus, the team reached out to many different schools and leisure centers for collaboration and professional assistance of teachers and psychologists. Nevertheless, the efforts were unsuccessful after a period of delays and cancellations. Most of the reasons revolved around: lack of interest from the institutions, the complexity of the circumstances, heavy teaching load, and even sudden COVID-19 outbreaks.

To face this challenge, the team decided to create the *KidReporter from Earth* workshop. Inspired by the KidReporter [54], the workshop was adapted for the research purposes, the online requirements, and defined as an individual workshop. The design of a single-participant version of the workshop would address the hardships encountered when requesting the institutions to find pairs of children that were also friends. Moreover, it allowed the team to extend the initial plan and reached out to family, relatives, and acquaintances with children in the target age group. Ultimately, Swedish and Peruvian children participated in the *Mission from Mars* and *KidReporter from Earth* workshops, guided in their respective languages. The remote format allowed a smooth transition towards the international facilitation of both participatory workshops.

- **Mission from Mars Workshops**

The goals of the *Mission from Mars* workshop was to understand children's knowledge about the spread and prevention of a viral infection. To collect their inputs and experiences from the current pandemic, the team organized this participatory design workshop as follows:

The workshop setup included the two researchers and one collaborator: one person was in charge of the facilitation, guiding the children and explaining the tasks; another person was responsible for the technical aspects of the online meeting, and one last person role played the curious martian by using a voice changer to simulate a translator. As for the participants, the team required that the children were either friends or acquaintances that felt comfortable talking to each other. They could be either be together in a physical location or collaborate online. Before the meeting, the team delivered consent forms specifying all of the workshop's details to parents and guardians.

The team invited the children into a Zoom meeting where the two of the researchers introduced themselves as secret agents and requested the children to pick code names to be part of a top-secret mission. The agents revealed a message written in cryptic characters containing a mission for the children. The second researcher simulated the translation of the message by a supercomputer using an animated web page 5.4. The cryptic message read: "w3 h4ve b3en ob2erving hum4nz for a whi1e. why are there no people 0utside all over the w0rld? 1s it a new hol1day?". The facilitator explained that the message came from an unknown 'Martian' currently orbiting Earth, so the children would need to explain the situation to the alien. The team provided no visual representation of the 'Martian' instead only showing a satellite video feed of Earth, hoping that it would inspire the children to use their imagination.

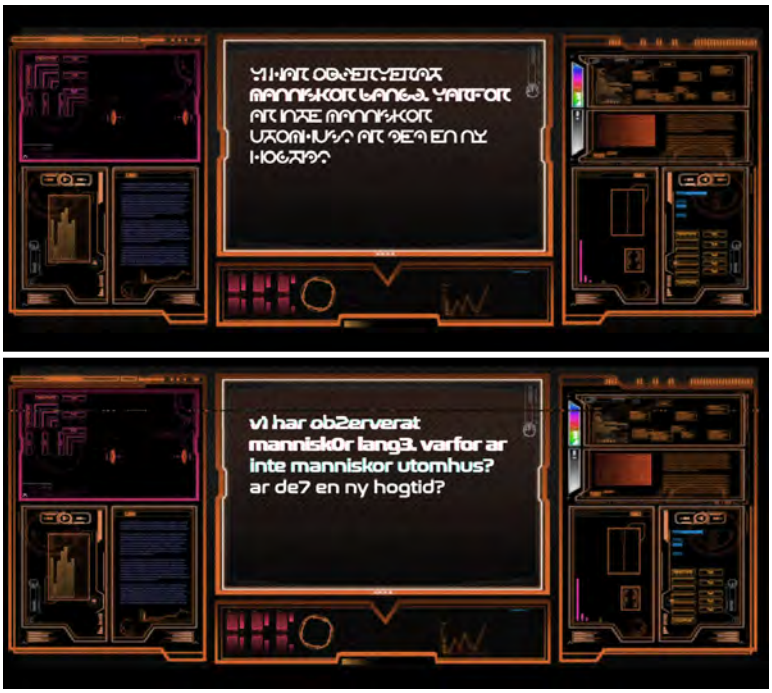

Figure 5.4: Simulated translation to Swedish language

After the children guessed the message was referring to the pandemic, the agent playing as a facilitator requested the children to gather any three objects that could better explain the situation to the 'Martian' while the team pretended to establish communications.

Once the children brought up the objects, the facilitator welcomed the curious 'Martian' (played by the collaborator using a robotic voice changer) and the alien to the young secret agents. First, the 'Martian' asked questions about the objects the agents brought; then proceeded to ask a question in regards to the pandemic, spread, and prevention of viral infections, differences in life, and social aspects before the pandemic. The questions were phrased as out of genuine curiosity and as an unstructured interview, using silly questions to make the activity entertaining. After addressing all questions, the 'Martian' bid farewell and thanked the young agents, and then the facilitators thanked the participants, declaring the mission a success and displaying their certificate of participation. The team sent certificates to the parents/guardians after the workshop a sign of gratitude.

Before the facilitation of the workshop with children, the *Mission from Mars* online was tested two times with adults and design experts to get general feedback and a better idea of what type of inputs to expect. The workshops were facilitated to two pairs of participants in English, lasting between 30-40 minutes. These experimental sessions led to adding a requirement to gather objects to explain the pandemic. The participants' answers also provided a better understanding of possible themes. Likewise, based on feedback, the 'Martian' proceeded to ask agent by agent about the items that the children

brought.

The team conducted the online *Mission from Mars* with three separate children pairs, two of them in Swedish and one in Spanish. All of them lasting between 20-30 minutes. The perception of the workshop was very positive, and the children felt very motivated to answer questions and provide their insights. Most children were talkative, but in the cases where the participants were shy, the facilitator and the different collaborators aided the flow of the conversation to even out the level of participation. The posterior data analysis presents the results of these workshops.

- **KidReporter from Earth Workshops**

The goals of the *KidReporter from Earth* workshop was to understand children's emotional perception of the COVID-19 pandemic. To collect their feelings, ideas, and experiences better, this participatory design workshop as follows:

The workshop setup included the two researchers. One person was in charge of the facilitation, guiding the children and explaining the tasks, and the other controlled the Miro board, a digital tool used for design and collaboration. The workshop required that the child participating would have a computer with a keyboard and a mouse. The activity required the child to use the remote control over the researcher's computer with the Miro board open. Before the meeting, the team delivered consent forms specifying all of the workshop's details to parents and guardians.

The team invited the children into a Zoom meeting where the two of the researchers introduced themselves as secret agents and requested the children to pick code names to be part of a top-secret mission. Identically to the *Mission from Mars* workshop, the agents revealed a cryptic message written in cryptic character, containing a mission for the child. The second researcher simulated the translation of the message by a supercomputer using the animated web page 5.4. The cryptic message read: "w3 h4ve b3en ob2erving hum4nz for a whi1e. why are there no people 0utside all over the w0rld? 1s it a new hol1day?". The facilitator explained that the message came from an unknown Martian. To avoid any language barrier and because their language is too complex to send them a written text, the young agent's mission is to answer the 'Martian' using only emojis. After the child guessed what the message is about, the team presented the Miro board as a tool for communication. The facilitator guided the child to use the emojis to answer two overarching questions: "How is life at school nowadays? and how was it before?" and "How do you do things between your family and friends nowadays? and how were they before?". The child was also encouraged to explain their thoughts while working on the task. After the child addressed the questions within the Miro

board and the conversations came to an end, the facilitators thanked the participant and declared the mission a success. The team sent the certificate to the parents/guardians later.

Before trying the workshop with children, the *KidReporter from Earth* workshop was tested once with an adult to get general feedback and a better idea of what could happen. The workshop was done with one participant in English, lasting 25 minutes. The team added new emojis thanks to the feedback and felt content with how children could use the canvas to express emotions.

The *KidReporter from Earth* workshop was facilitated to four children, three of them in Spanish and one in Swedish. The workshops lasted between 20 to 50 minutes (50 minutes due to technical issues). This workshop was, by far, the most complicated one because of the technical aspects. The researchers were aware of previous statements where Miro was addressed as a faulty tool for collaboration and participatory design with children [9], but those papers did not describe the details or nature of the faults. The team ran into many issues with mouse control when participants were using laptop trackpads. Similarly, the team had issues with the remote control feature in Zoom due to input delay and other inconveniences because of Miro's account requirement. All these, for the researchers, proved that Miro was a poor choice specially for participatory design with children online. Nevertheless, in general, the inputs from children were very much satisfying 5.5. More subjectivity and emotional connotations was showed in their answers, and the format provided a way to promote creativity while the participants expressed their opinions. Furthermore, in terms of the difference between age groups: the researchers noticed many complex arguments from older children (11-12) arriving at political statements. On the other hand, shyness might still play a significant role in individual activities for younger children.

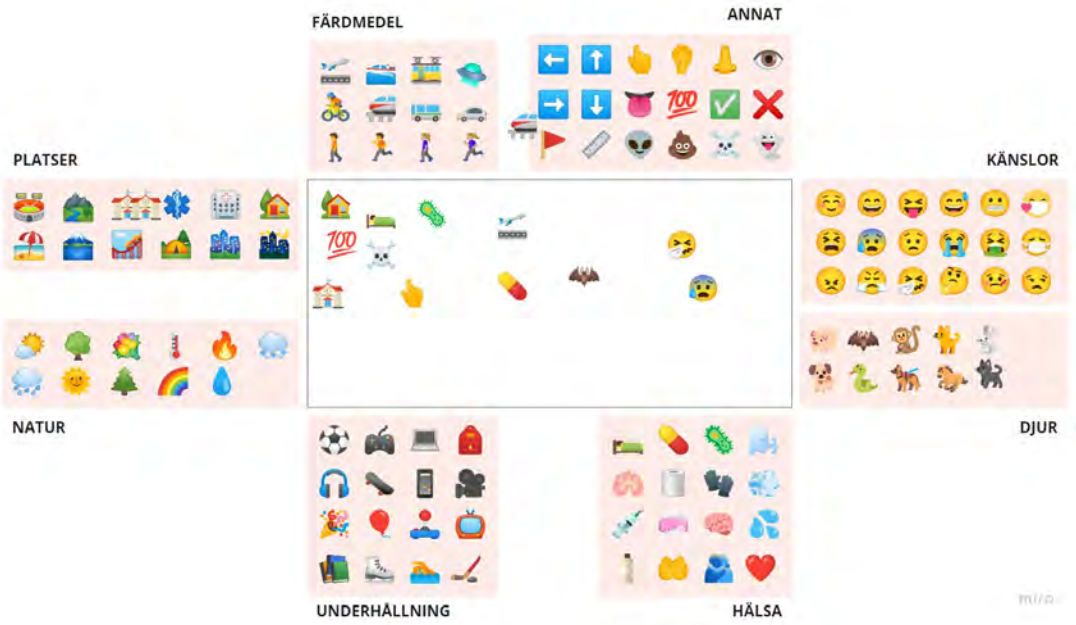

Figure 5.5: Result of a Participatory Workshop facilitated in Miro [1] - KidReporter

5.3.2 Defining the problem

The following section will describe a data analysis of the previous methods. The analysis focuses on the understanding of the problem at hand and the related learning goals.

5.3.2.1 Data Analysis

The workshops resulted in a lot of qualitative data and insights. This data required further processing, categorizing, and analysis to be of use in the design process. The team analyzed the data from both workshops individually using a two-step process and then compiled the insights together.

The results of the *Mission from Mars* workshop were, in general, far more objective in nature as the children attempted to give the 'alien' a factual account of events on Earth. Most interviewees from this workshop focused on explaining preventive measures, technical details of how the virus works, and social changes that they have witnessed.

The team found the data from the *KidReporter* workshop to be more subjective. The use of emojis had successfully facilitated emotional response and self-expression in the feedback received. These interviewees focused on their own experiences and feelings regarding the pandemic, noting emotional impact and social changes in their everyday life.

The team sorted data from each workshop by putting them into an affinity dia-

gram (Fig. 5.6). Each participant's feedback was categorized according to the same criteria to aid in pooling them together with other data. The categories came from themes found in the participants' answers. These were as follows: Social, Virus Mechanics, [Infection] Prevention, Symptoms, Emotions and Other (For the few responses that did not fit anywhere else).

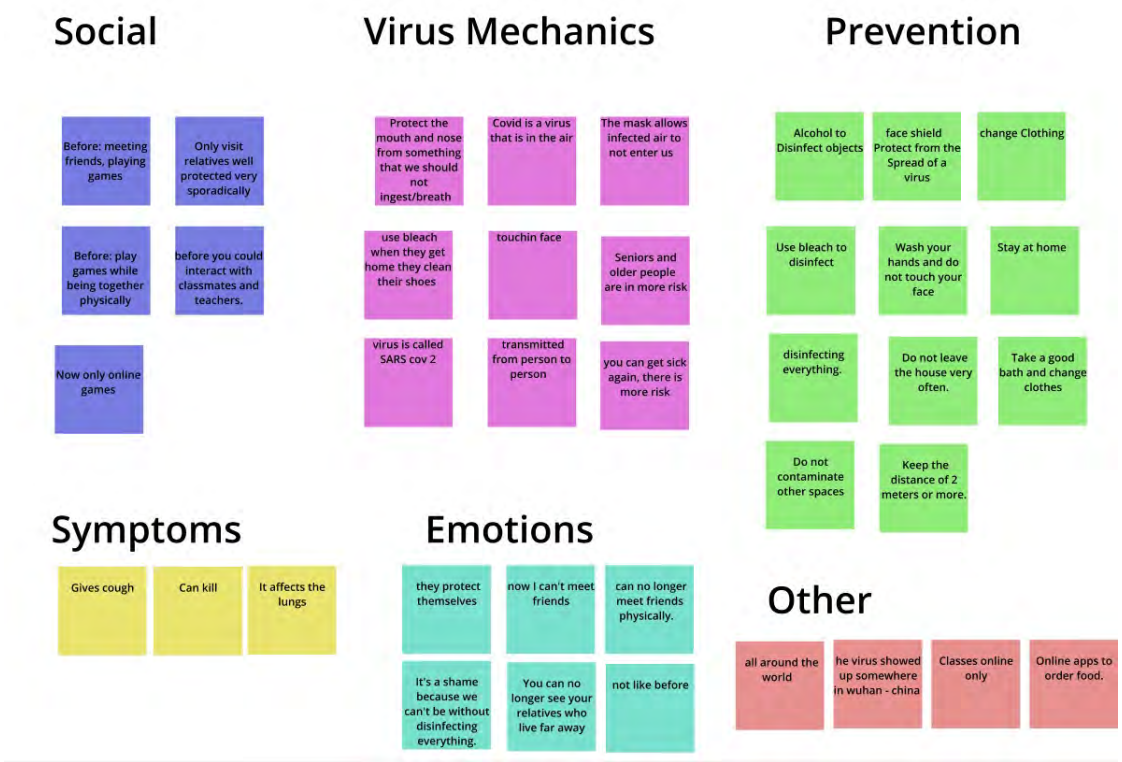

Figure 5.6: One of the resulting affinity diagrams

Finalizing the affinity diagrams made the answers much easier to handle. Identifying common patterns among the user data allowed for better grouping of feedback and increased understanding of users' opinions. The new format made it possible to move onto the second step of the analysis process, in which the results move from the identified themes into new underlying ones that are more insightful for the design process.

Creating these new themes consisted of finding an underlying theme in the feedback than what was superficially said. For example, one user said they missed being at school, which the team categorized as an emotional response during the affinity diagram stage. This response moved to a new category called *Emotional perception of the social circle* grouping it with other feedback relating to the impact of the COVID-19 pandemic on their social life and specific interactions with friends.

A new board with notes evolved to encompass 19 different categories as new themes surfaced, resulting in figure 5.7. The team learned much just from how the new categories mixed the old themes from the affinity diagrams.
For instance, a finding that proved valuable is that children saw home as a safe space

from the virus. The old themes involved show that this feeling comes from both informed understanding of the virus and emotional perception of safety at home and with parents. Finally, the children repeatedly expressed frustration out of all the restrictions and limitations that the pandemic brought.

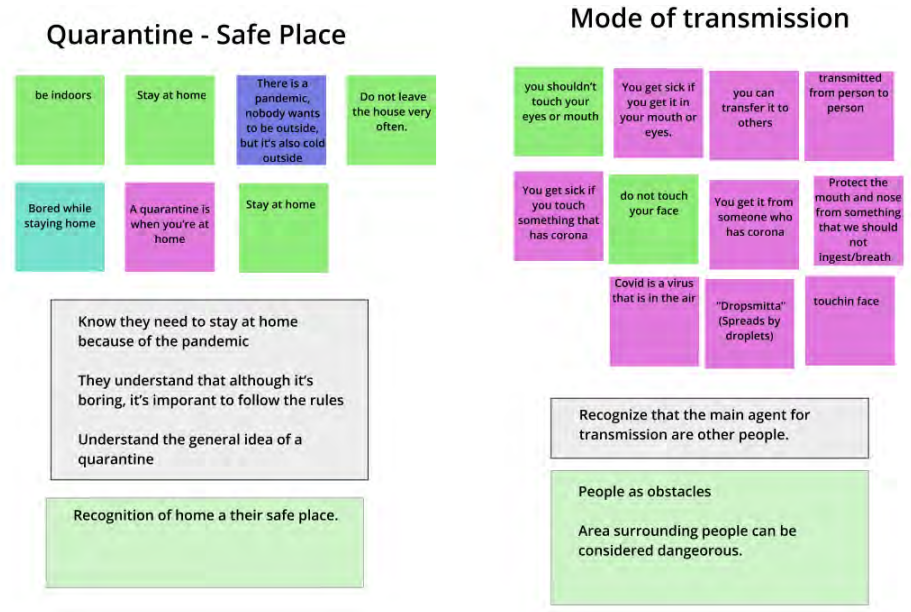

Figure 5.7: Example categories from the thematic analysis of the *mission from mars* workshop

To keep track of new insights, the team complemented each new category with two fields of notes. The first field served to note the interpreted insights, and the second field was for writing down spontaneous ideas of how it could reflect in a game. These ideas varied from abstract to specific game mechanics. The children recognized that an agent for transmission was other people, so the team came up with the idea that people could become an obstacle in the game. They felt safe at home, so another idea was to send the player character home when they ran into trouble.

The team found the findings from this analysis valuable and decided that it had provided a sufficient knowledge base to move away from exploring the problem space and into an exploration of the solution space.

5.3.2.2 Results from Participatory Workshops

The workshops with children successfully provided insights into the children's understanding and perspective of the current COVID-19 pandemic.

- **New Normality**
  Children are aware of how the world has changed with the pandemic. Comments like *"It's not like before"* and *"It hasn't always been like this, it used to*

be normal" led to this understanding.

- **Frustration**
  Children are emotionally frustrated with the lack of physical and social interactions. They miss their friends, relatives, and family because they can't meet them like they used to. Comments like *"You can no longer see your relatives who live far away"*, *"Miss seeing people"*, and *"now I can't meet friends"* led to this understanding.

- **Prevention**
  Children are aware and very knowledgeable when it comes to prevention measures. Their comments involving social distancing rules, avoiding touching one's face, frequently washing hands with soap, the use of masks, and many others led to this understanding. The prevention measures became more thorough when the children experienced tougher restrictions on their home country.

- **Safe Place**
  Children identify their homes as a "safe" place. The recommendations they provided as *"Do not leave the house very often"*, *"Stay at home"*, and *"Be indoors"* led to this understanding.

- **No Symptoms Details**
  Children were not very knowledgeable in terms of the symptoms of a COVID-19 viral infection. Although some children provided technical descriptions of the virus, like *"a virus is a little thing that infects and tries to stay alive using our bodies"* or *"I brought a ball, shaped like corona"*, the only symptom brought up by a participant was that *"it gives cough"*.

5.3.2.3 Learning Goal

After the inputs from the previous workshops, social distancing was chosen as the main topic to address understandings of spread and prevention of viral infections. The teamed deemed social distancing as the most beneficial prevention method for young children to learn. Children do not have a say when it comes to other preventive measures like quarantines and vaccinations. Nevertheless, they could contribute positively to their environment by learning something they can apply in their everyday life. With this phase complete, the exploration of the solutions space concludes, and the path is open towards exploring the solution space.

5.4 Exploration of Solution Space

This section will describe the execution of the later phases of the google design sprint. These phases follow the creation of a design artefact from conception by sketching through evolution by assessment to design solution.

5.4.1 Defining the Solution

The second part of the "defining" phase crosses over into the domain of the solution space. The team works in this phase to define what a possible solution could look like and what requirements it would have. The methods included in this part of the process served to help narrow down the scope and ideas of the team before sketching.

5.4.1.1 Competitive Analysis

The first thing that the team did to narrow down ideas was to look at competitors' solutions to similar problems, choosing a handful of infographics, games, videos, and interactive experiences about the COVID-19 pandemic for analysis. The included visualizations were initially picked by whether they were made for the same target audience as the project intends, but few such visualizations exist. The team, therefore, chose to complement the choices with a few visualizations meant for adult audiences.

The analyzed visualizations were as follows:

- **The Coronavirus Explained & What You Should Do**
  Educational video by YouTube channel *Kurzgesagt*[55]

- **Can you save the world?**
  Coronavirus themed game that stresses social distance made by *Martin Jacob*[56]

- **The importance of handwashing**
  Interactive video about handwashing by *LumaOne*[57]

- **What is Coronavirus (COVID-19)? All You Need to Know**
  Infographic with interactive elements by *Mahnoor Sheikh*[58]

- **Inside the Coronavirus**
  Educational article with detailed animations *Scientific American*[59]

- **Plague Inc: Evolved**
  Video game about pandemics by *Ndemic Creations*[60]

Each visualization was tested briefly on its own, with all notable positive and negative aspects written down for later comparisons. The notes helped in getting an initial overview of what makes the visualizations unique and enjoyable. For clarity, the details of the visualizations went through a similar thematic analysis to the workshops. All of the notable aspects were color-coded according to common themes and placed groups in a Miro board as shown in Figure 5.8.

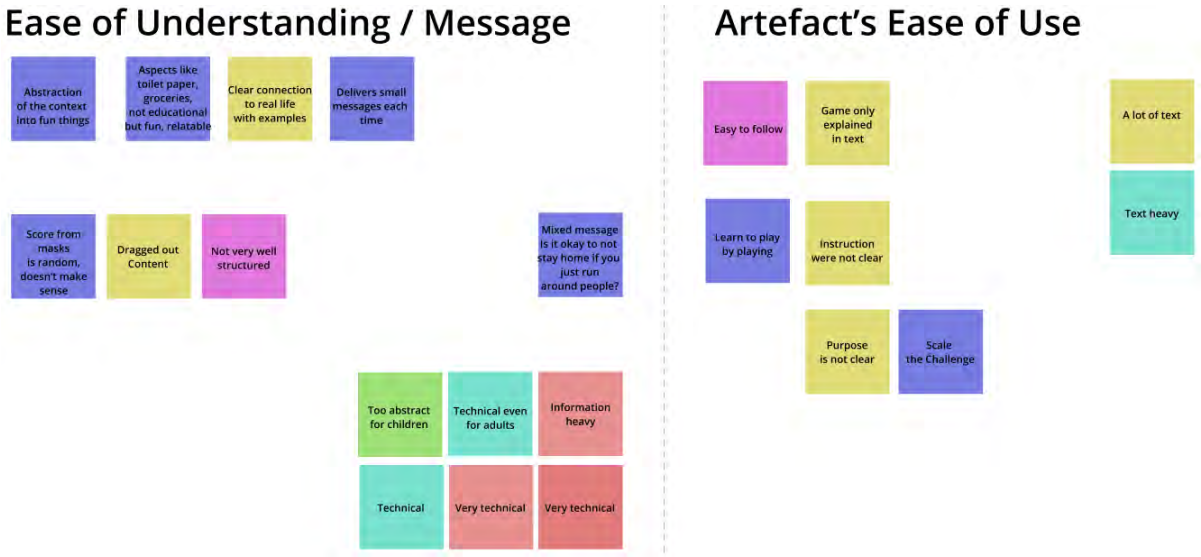

Figure 5.8: Part of the thematic analysis of existing visualizations

5.4.1.2 Prioritization

After organizing the findings from the analysis, the team could create requirements for a visualization. The defined themes from the thematic analysis were reused in a *Do's and Don'ts* chart (Figure 5.9) to aid in grouping requirements.

This chart (Figure 5.9) initially followed the MoSCoW method, but the team wanted to focus more specifically on which things to avoid, which the MoSCoW method isn't well suited to do. The chart fulfills a similar function to the MoSCoW one in laying out the priority of features for the project. The chart shows what the team wants to include and what is considered a possible inclusion. The chart also clearly shows what the team wants to avoid in the final design by explicitly stating these.

Lastly, the chart would guide the rest of the design process by outlining the absolute requirements for the visualization. For example, the team decided that visualizations following a flat design style were easiest to follow and most engaging, therefore deciding that the planned design should also follow a flat style. In a similar vein, the team felt that the technical detail of visualizations such as the one from the *Scientific American* was far too hard to follow for a young audience and should be something to avoid.

5.4.1.3 Summing up

The final step before the sketching phase consisted of summing up the previously gathered ideas and requirements. The team required a visualization that would be interactive, educational, and engaging while being technically feasible based on the team's experience. Based on the findings regarding the targeted user group, the team decided that some sort of game would be best suited to meet the set goals.

The team was most knowledgeable about 2D illustrations and web technologies,

so it was most fitting that the visualization would take the shape of a 2D Javascript artefact. With this decision, the next step included listing genres of interactive artefacts that the design could encompass.

By consulting the competitor analysis and comparing popular games within the user group, the team defined the possible games within the chosen technical framework. The chosen genres were: Gamified simulation, puzzle, strategy, visual novel, platformer, and interactive infographic.

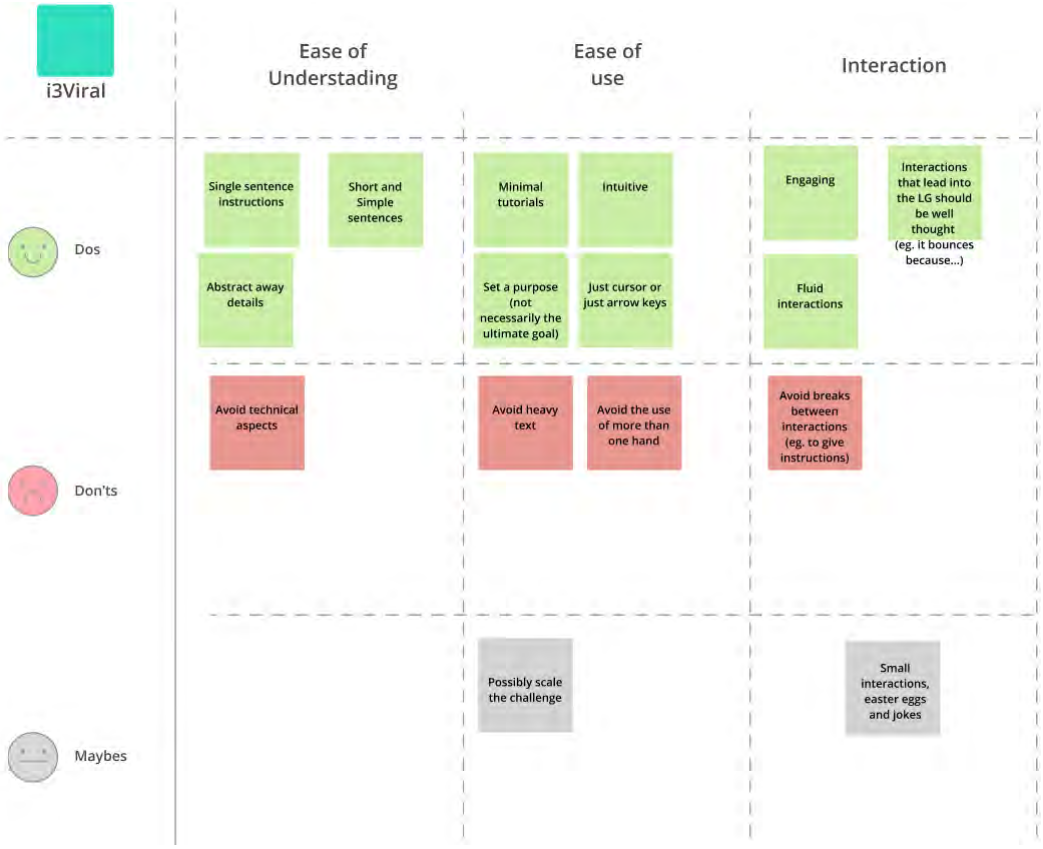

Figure 5.9: Part of the resulting chart

After some deliberation, including weighing the pros and cons of the various genres, their popularity among children, and potential for educational messaging, the team decided to discard visual novel, 2D platformers, and interactive infographic.

5.4.1.4 Backward Design

The backward design model aims to create a learning experience by defining three stages: Desired Results, Assessment Evidence, and Learning Plan. Stage 1 is the first step in exploring the solution space where the team approached the Learning Goal.

Stage 1 - Desired Results

- **Established Goal**
  In concordance with the insights determined within the previous design meth-

ods, and upon further review of prevention measures [61], a detailed definition of the learning goal for Stage 1 of the backward design was stated as seen in Figure 5.10:

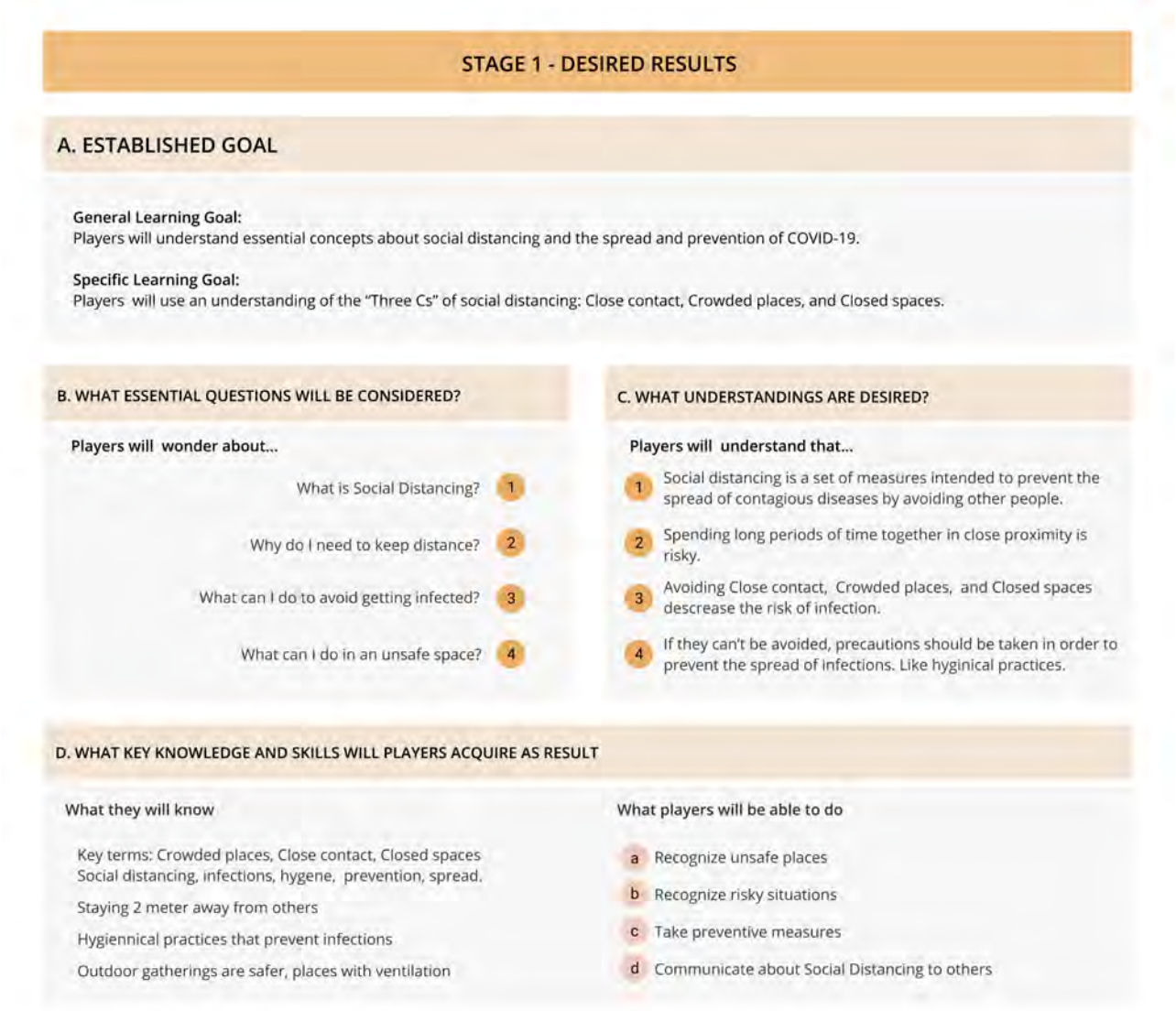

Figure 5.10: Backward Design. Stage 1 - Desired Results

The general learning goal is for players to understand essential concepts about social distancing and the spread and prevention of COVID-19. Furthermore, this goal becomes much easier to approach when framed as a specific goal where "players will use an understanding of the *Three Cs* of social distancing: avoiding Close contact, Crowded places, and Closed spaces".

The team selected the *Three Cs* as a specific way to tackle the Learning Goal due to its simple nature. Although children showed familiarity with basic social distancing rules, complementing their knowledge with more concrete examples

and definitions for avoiding close contact, crowded places, and closed places seemed worthwhile.

- **Questions and Understandings**
  After stating the goal, the following sections of Stage 1 (B. Essential Questions and C. Understandings) seek to clearly define what questions children will ponder while learning and what understandings they should arrive at by the end of the learning experience.

- **Key knowledge and skills**
  Lastly, looking further into knowledge and skills provided insights into how relatable situations could deliver the learning goal to children. Some scenarios considered by the team were the recognition of unsafe places, recognition of risky situations, taking preventive measures, or communicating appropriately about social distancing.

5.4.2 Sketching the Solution

The sketching phase served to align the vision for the solution within the team and generate possible design ideas. Initially, the plan was to tackle the rich emotions framework already by this phase, but the team deemed it too early as planning for emotions was difficult with so many details missing and no clear direction yet.
The *rich experiences* framework was postponed until further development of the solution. As for the sketching phase, the team decided to expand the scope and do multiple iterations of the Crazy 8's method.

5.4.2.1 Crazy 8's

The team planned to do a single session of Crazy 8's to find ideas but ended up repeating the method for each of the genres decided upon in the defining phase. A sketching session was held for puzzle games, strategy games, and gamified simulations one after another as the team wanted to explore each genre properly before settling on an idea.

Doing three rounds of Crazy 8's proved valuable even after the team decided on a top-down/strategy game. The ideas from the other genres still inspired mechanics within the game and could be included on a smaller scale alongside the main gameplay loop. Figure 5.11 shows generated ideas for the top-down/strategy genre, with features that the team deemed interesting highlighted in green.

5.4.2.2 Crazy 8's Sharing and Voting

One by one, all the sketches were presented by the team members. Each drawing was briefly discussed and then moved forward to the next.
Lastly, to round up the Crazy 8's, each member of the team selected seven features

that seemed most interesting resulting from all the different sketching sessions. The selection is visible in Figure 5.11, with the intriguing features circled in green. In total, the team selected fourteen ideas to consider for the creation of the upcoming solution sketch. Among the considerations were: A top-down view of a supermarket, a count-down timer, a battleship strategy perspective, use of power-ups.

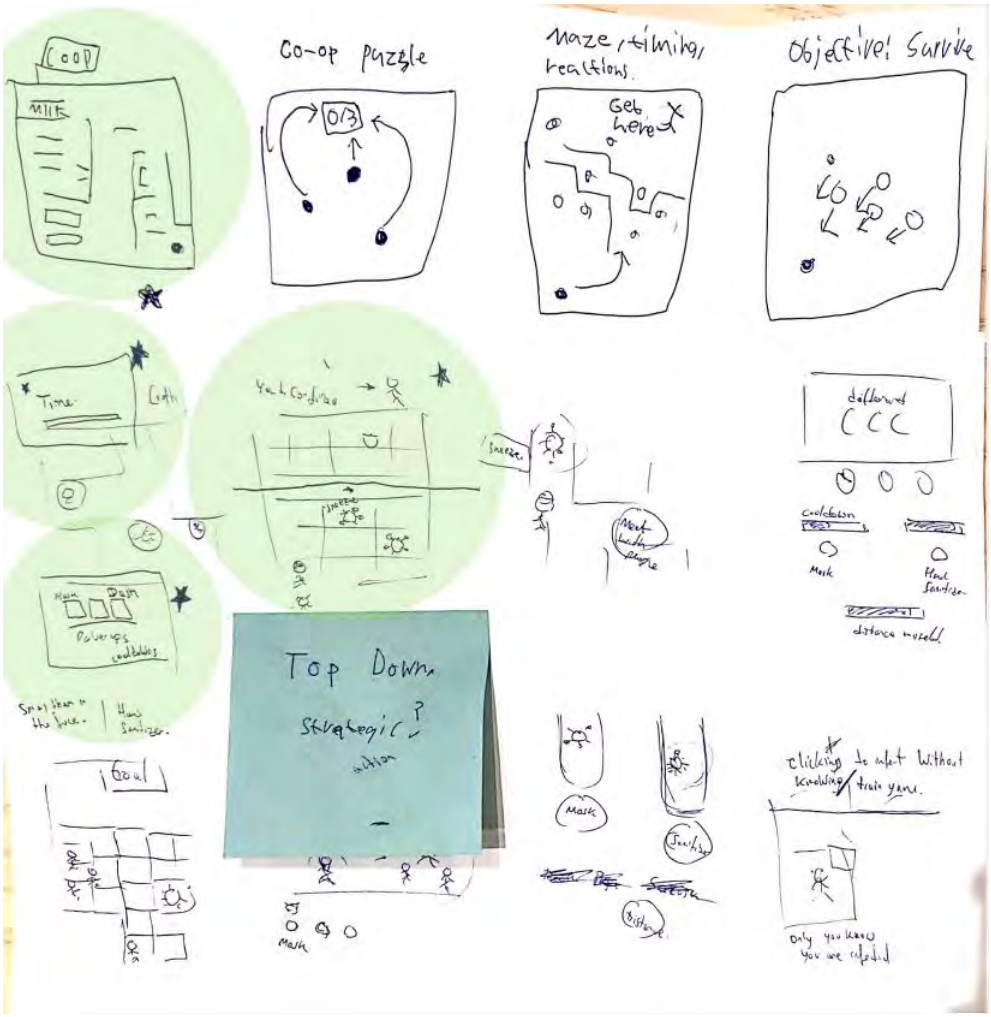

Figure 5.11: Crazy 8 sketches for the Top Down/Strategy genre

5.4.2.3 Solution Sketch

After discussing the crazy 8's sketches and identifying appropriate game mechanics, the team did one final sketching exercise by creating solution sketches. These solution sketches would be crucial as they would form the basis for the rest of the design. To aid in ideating and choosing the right idea, the team brought in an expert advisor to act as a third team member during this exercise. Creating the solution sketches with the outside expert was done through a video conference due to the pandemic.

After a brief introduction for the outside expert, the team took 15 minutes to draw solution sketches, resulting in the three sketches show in figure 5.12. The intention

was to combine ideas from the previous crazy 8's exercises with new ideas to propose a novel solution.

Figure 5.12: The three solution sketches from the exercise

The three sketches represented a basic gameplay concept. To start, the player would select a map, after which the player would need to find tasks to solve and to solve them, the player would need to play a minigame. Here, the team also decided upon creating a game that would be playable with just a keyboard.

5.4.3 Deciding the Solution

The following design methods seek to converge the ideas into one well-thought concept by using decision-making exercises. All the ideas that the previous design methods brought up will be discussed and considered.

5.4.3.1 Presenting the Solution Sketches

Once the team had finished the solution sketches, the intention was to pick one of the designs (Or parts of one) through voting. The outside expert that joined as a temporary team member acted as a tiebreaker. That plan needed reworking once

the team presented their sketches since each team member focused on entirely different parts of the design, as shown in figure 5.12

Rather than redoing the exercise, the team agreed to fuse all ideas into a single solution. The group decided that doing the exercise once was enough partly due to the schedule of the expert. Since the sketches didn't overlap, for the most part, the ideas presented weren't mutually exclusive and could all fit together. The fusion would result in a satisfactory solution containing a level selection screen or map, a top-down view of rooms in which the player needs to avoid bumping into other people, and some form of minigames placed on the map.

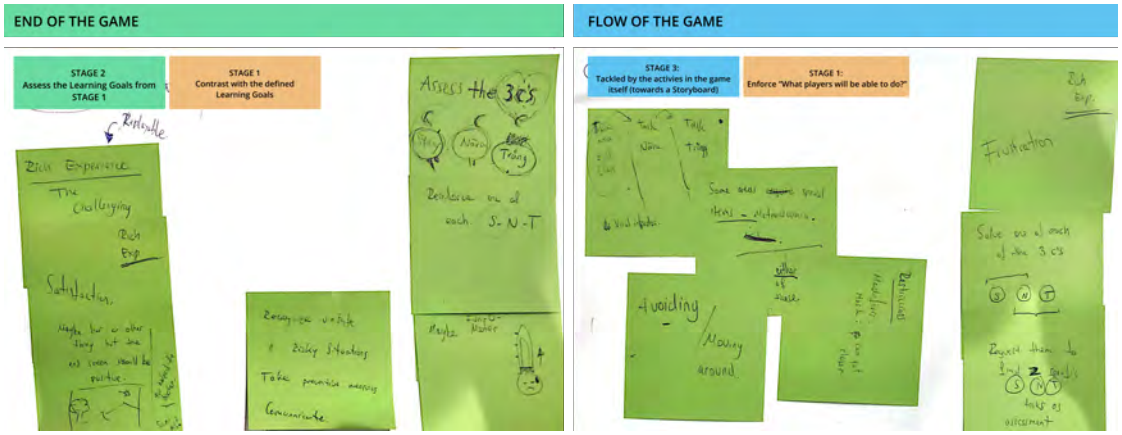

Figure 5.13: Drafts for the analysis of Stage 2 and Stage 3 of the Backward Design

5.4.3.2 Backward Design - Stage 2 and Stage 3

The backward design process continued after the creation of the final solution sketch. Within the project, the learning experiences and learning assessments exist within the same digital solution. For instance, it made sense to analyze and define both, the *Stage 2 - "Assessment Evidence"* and the *Stage 3 - "Plan Learning Activities"*, one after the other.
Following the backward design process, the team addressed *Stage 2 - "Assessment Evidence"* first. The team identified the end of the game as the most appropriate point to review those learning assessments and determine success. Afterward, the project moved onto *Stage 3 - "Plan Learning Activities"*. In contrast to Stage 2, most of the learning experiences have a place within the flow and progress of the game itself.

Figure 5.14: Backward Design. Stage 2 - Assessment Evidence

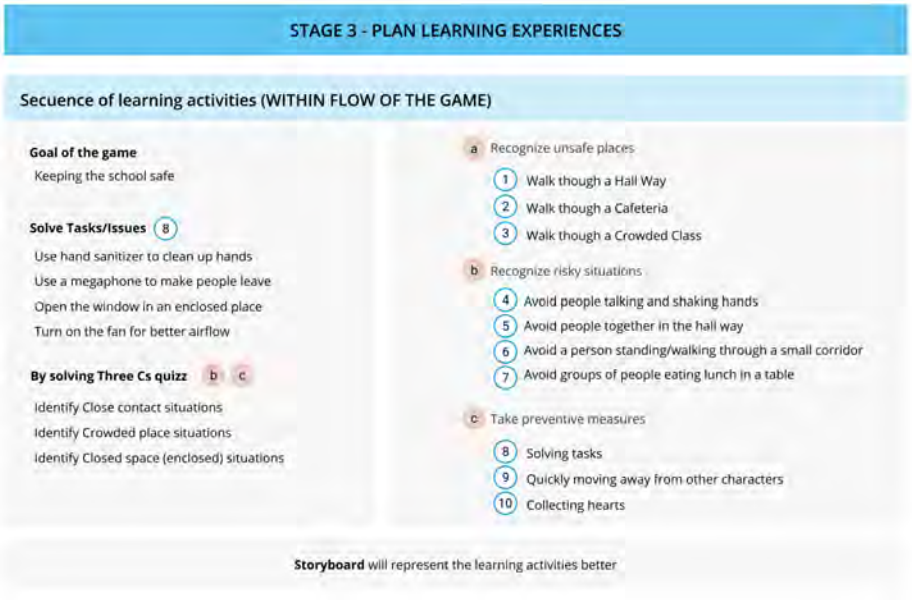

Figure 5.15: Backward Design. Stage 3 - Plan Learning Experiences

Within this brief discussion and analysis (Figure 5.13), the Learning Goals, and ways to assess them, were brought up to the table. Later, a more thorough specification

of the assessment evidence developed. Thus, Figure 5.14 represents how the players' actions are assessed in contrast to the Learning Goals from the *Stage 1 - Desired Results* of the *backward design*. Such is the case of understanding the game's mechanics, solving the quizzes adequately, and winning/losing the game. Additionally, the team's evaluation methods collect complementary assessment evidence.

Similarly, a thorough analysis of Stage 3 defined the different learning activities, as seen in Figure 5.15. The game's goal was to keep the school safe, which required the player to solve tasks around the school. Solving a task/issue implied solving a quiz that would assess the players' understanding of close contact, crowded places, and closed spaces. To navigate between tasks, the player would have to walk around different areas in the school, avoid risky situations and take preventive measures that will also contribute to their learning experience.
After setting all these activities, the team decided to move forward in the design process and create a storyboard, opting to further understand and develop solutions within the rich experience framework.

5.4.3.3 Rich Experiences

After the brief analysis of the *rich experiences* framework within the *backward design*, the team decided to expand on it and define the desired experience better.
The selected rich experience is called "the challenging" [24]. This experience requires the players to feel frustrated with some challenges in the game. Later, the players can overcome the challenges by focusing and using the controls adequately (considered by default as the Protective Frame in scenarios like complicated puzzles). Overcoming these challenges result in a highly satisfactory experience. The team made the conscious decision not to work with emotions that could misdirect or reinforce other negative aspects of the potentially frightening topic, dismissing emotions like fright or anxiety entirely. Moreover, as explained before, the results of the participatory workshops suggested that children are frustrated with the pandemic's restrictions. Thus, the team considered "the challenging" rich experience as an adequate emotion for a learning purpose; since the game will provide the players with tools (movement control and knowledge) to a satisfactory result - staying safe, even in the real world.
In consideration of the game's dynamics, the team evaluated the desired rich emotion within two dimensions: the flow of the game and the end of the game, as seen in Figure 5.16. Within the game, frustration may prime over other emotions by facing the player with challenging activities like avoiding characters, losing lives, or even losing the game. Which, in turn, implied that the difficulty of the game should be something to note. The protective frame, a control frame in this scenario, is introduced to the player in the shape of the character's movement control. Lastly, the player should have a satisfactory experience once they understand the mechanics, evade risky situations, and solve the task at hand. The team planned to greatly enforce the frustration and satisfaction experienced by the losing or winning end-screens, respectively.

With this perspective in mind, the team wrapped up the initial expectations for emotional experiences within the game.

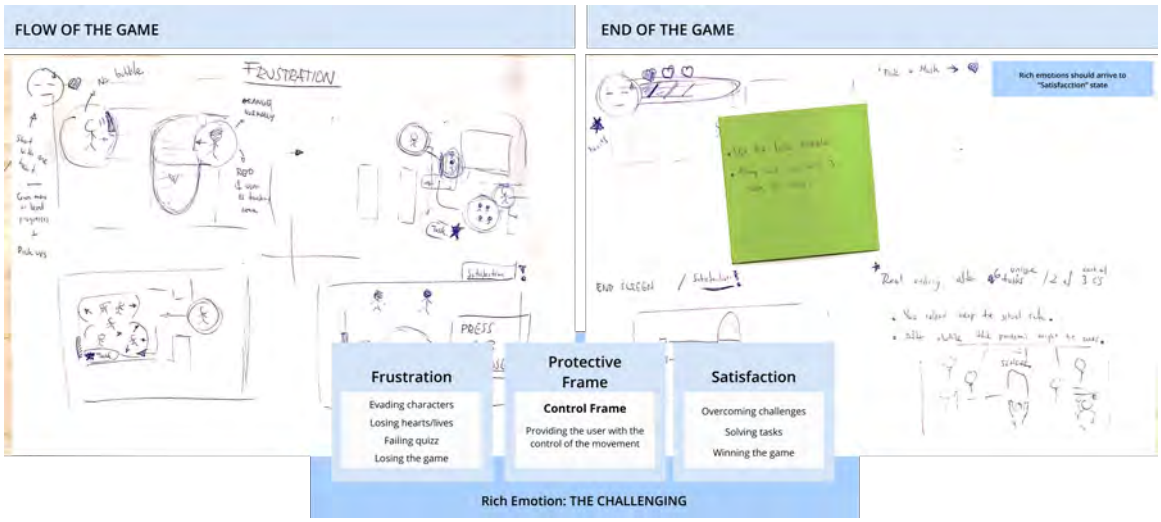

Figure 5.16: Representation of the rich emotion in the storyboard

5.4.3.4 Moodboarding

The creation of a mood board followed a reasonable perception of the solution and the desired outcomes. The illustrations were used as deciding factors for different aesthetical and inspirational aspects of the game. Throughout the design process, some elements like the characters, look and feel of UI elements, and others were changed and adapted to fit the ambitions for the solution.

Figure 5.17: Final mood board

The last version of the mood board can be seen in the Figure 5.17. This mood board was used a visual guide during the whole prototyping phase.

5.4.4 Prototyping the Solution

With a good grip of the task at hand and with all the fundamental design choices made, it was time to move onto prototyping. This section details the methods and processes of creating the final MVP, from storyboarding and prototyping to coding.

5.4.4.1 Storyboarding

The creation of the storyboard started by reviewing all the previous methods. The storyboard, for the first time, would display the whole game's experience, which needed the consideration of the *solution sketch*, *backward design*, and *rich experiences*. Additionally, the team planned to make the whole experience last no longer than five minutes by design. Later, several scenes were designed to represent the gameplay, as seen in Figures 5.18 and 5.19.

The first three frames describe the starting screen of the game, character selection, and an introductory area to learn the game controls. The following frames illustrate the interactions with the tasks and with other characters in the game. Later, in Figure 5.19, the quiz mechanic is explained together with the game's replayable characteristic; and the hearts/lives feature.

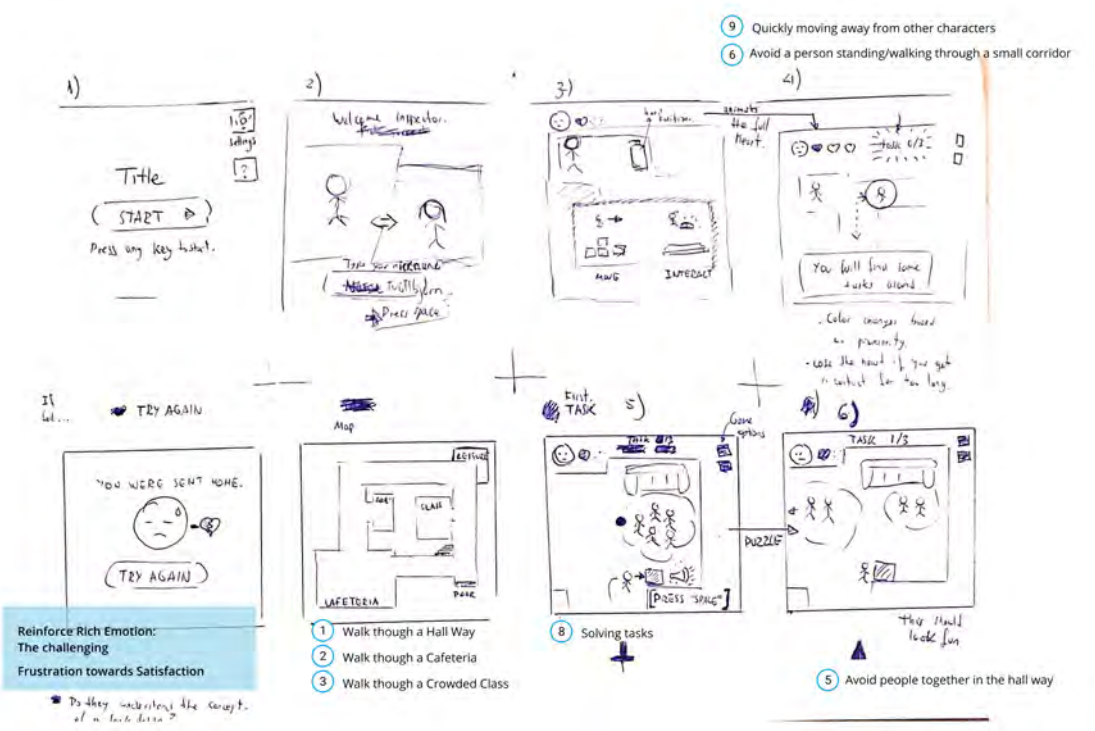

Figure 5.18: Storyboard Scenes - Part 1

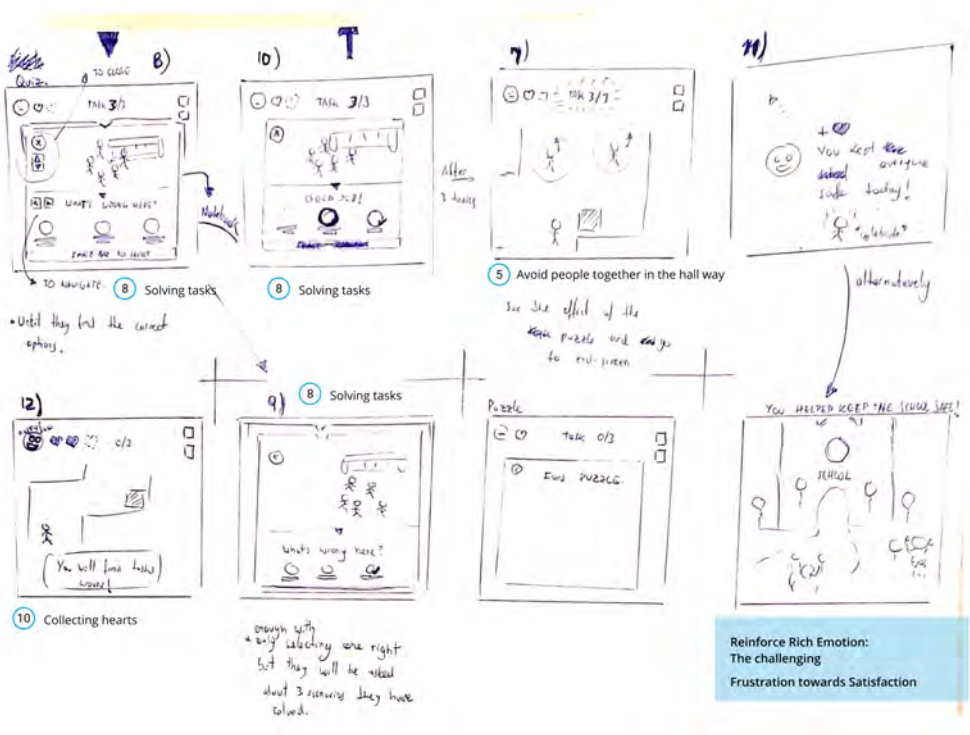

Figure 5.19: Storyboard Scenes - Part 2

Furthermore, the message of the losing and winning screens of the game (Figures 5.18 and 5.19) are reinforced within the scene to keep the *rich experiences* framework in mind. Likewise, scenarios reflect the activities corresponding to the *Stage 3* of the *backward design*.

5.4.4.2 High-Fidelity Prototype

The team gathered video game assets, tilesets, characters, illustrations, safety signs, and other objects for the game. All the assets followed the design direction of the mood board (Figure 5.17) and allowed the team to keep a consistent prototype design. Nevertheless, some elements required digital editing in tools like Adobe Photoshop and Illustrator. The prototype was designed in a prototyping tool called Figma [62] and followed technical constraints defined by the Minimum Valuable Product (MVP), like asset sizes. Which, in turn, made the assets from the prototype easier to export and deploy to the MVP.

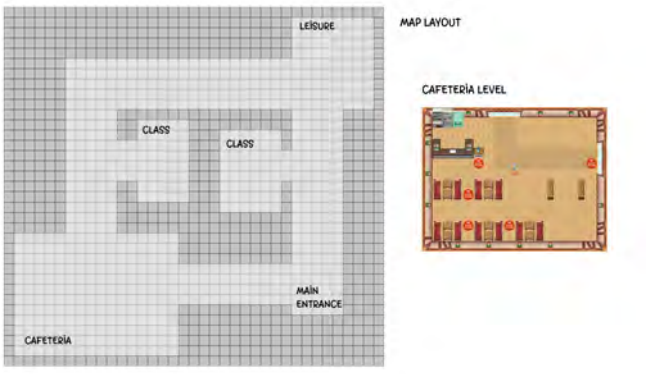

Figure 5.20: First Prototype of the Game

The first prototype was designed following the storyboard (Figures 5.18 and 5.19). The prototyping phase started with the creation of the map layout and the cafeteria distribution (Figure 5.20) as the first level in the game 5.21. After evaluating the time constraints and team's capabilities at that very moment, the team decided to work only within the cafeteria level, with the possibility of adding more levels later in the process.

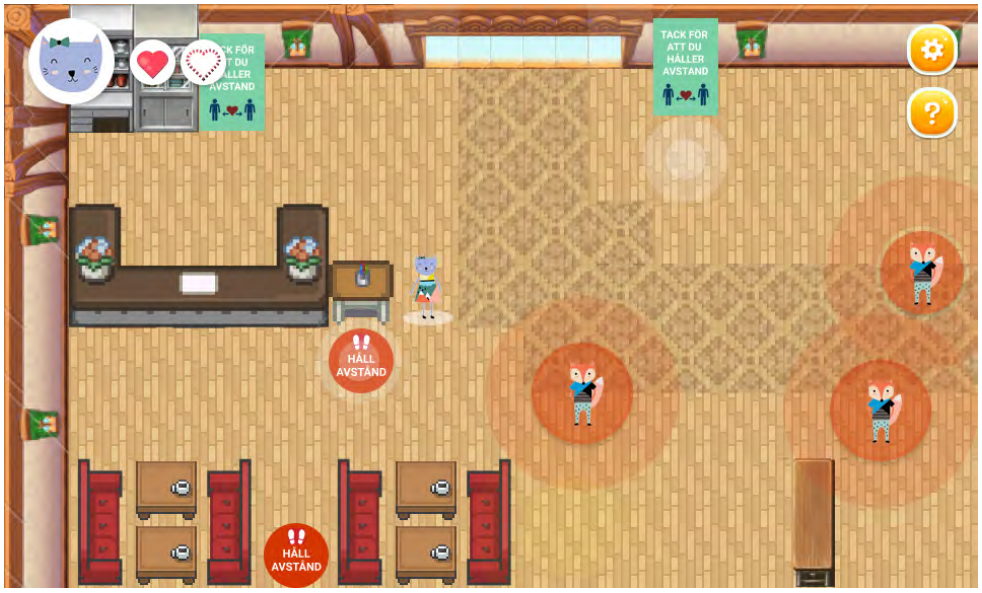

Figure 5.21: First Prototype of the Game

This prototype was further developed to displayed all the different scenes from the storyboard. Thus, the following sets of figures will describe the extend of the prototype:

- Figure 5.22 displays the title screen of the game and the character selection.

Figure 5.22: First Prototype - Starting Screens

- The tutorial level is introduced in Figure 5.23, consisting of an small area where the player would learn the mechanics of the game.

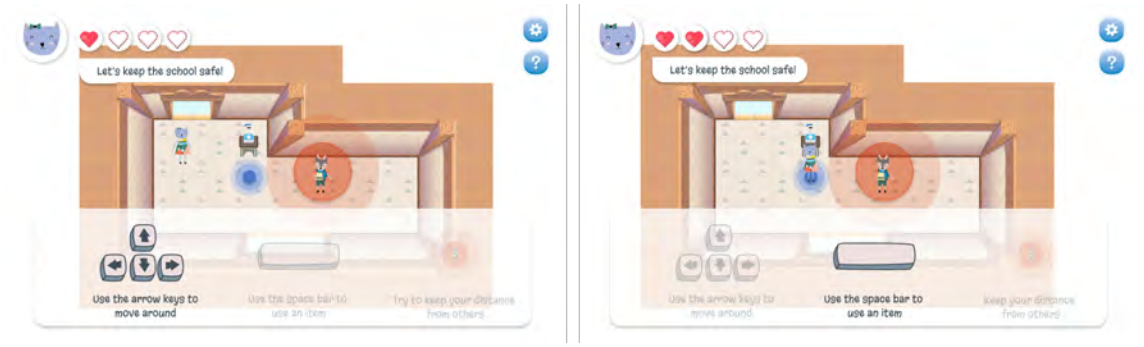

Figure 5.23: First Prototype - Tutorial Level

- The cafeteria level, in Figure 5.24, presents the game's largest area. On it, the player will solve most of the tasks. Moreover, the player will face the challenge of navigating around the rest of the characters without losing lives.

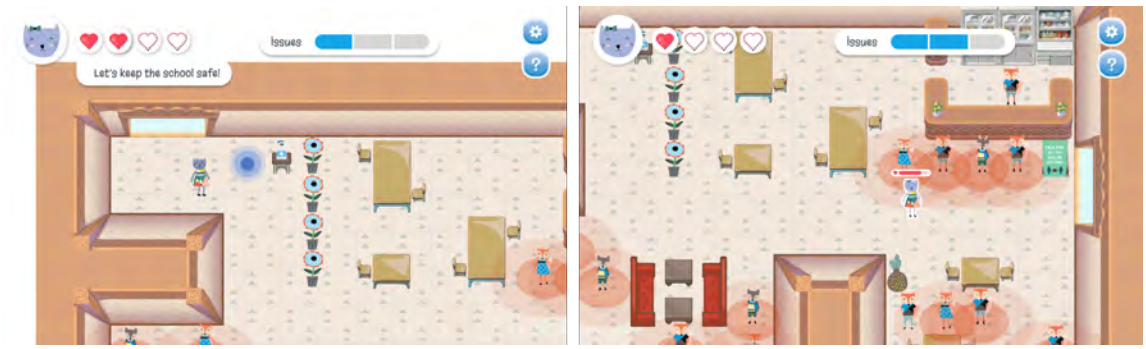

Figure 5.24: First Prototype - Cafeteria Level

- Quiz mechanics can be seen in Figure 5.25. In the figure, the prototype illustrates how the quiz responds to the player's selection of correct or incorrect answers.

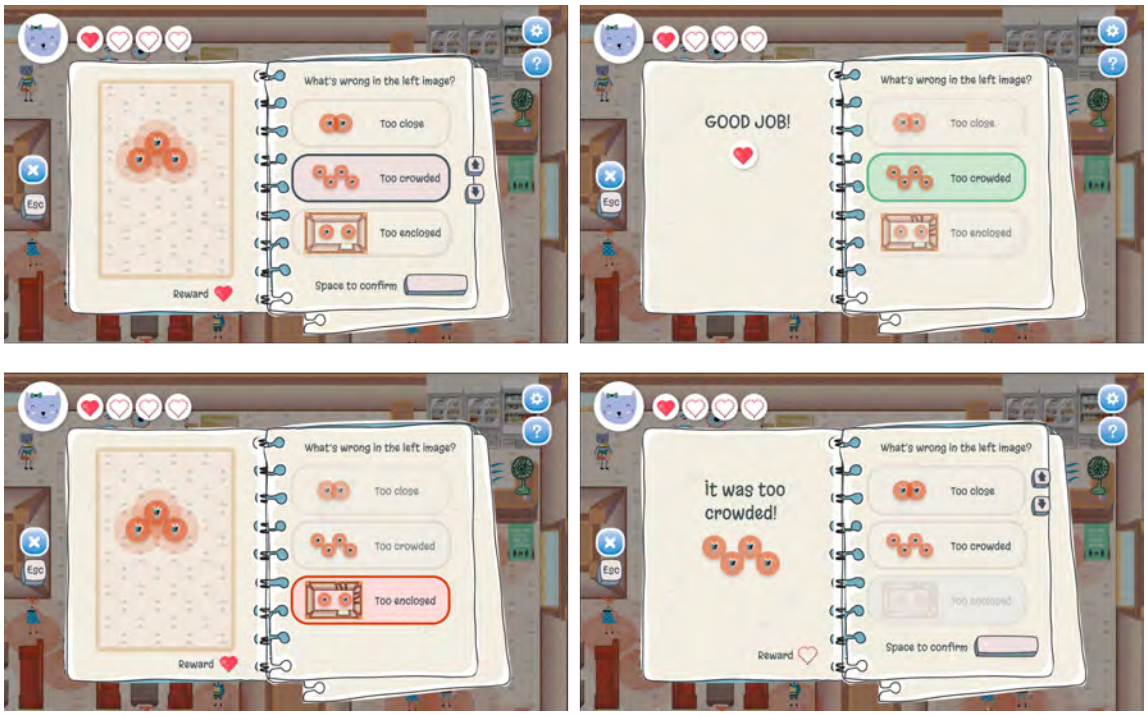

Figure 5.25: First Prototype - Quiz

- Lastly, Figure 5.26 displays the losing and winning screens of the game.

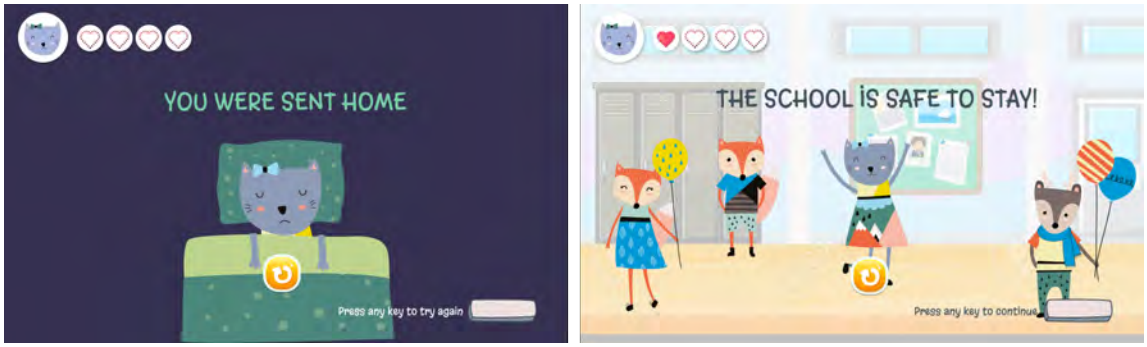

Figure 5.26: Prototype - End Screens

The Prototype in Formative Evaluation

The prototype functioned as a clear representation of the desired outcome. For instance, its use was as a guide to developing the visual appearance of the MVP. Later, the prototype complemented the MVP's formative evaluation with experts. This evaluation was carried out with experts and provided valuable feedback for the flow of the game. The prototype and the MVP addressed the feedback and received improvements.

Lastly, by the time of the first evaluation with children, the MVP contained most of the functional features described by the prototype. For instance, significant new requirements ended up getting prototyped again; such is the case of the notebook 5.27.

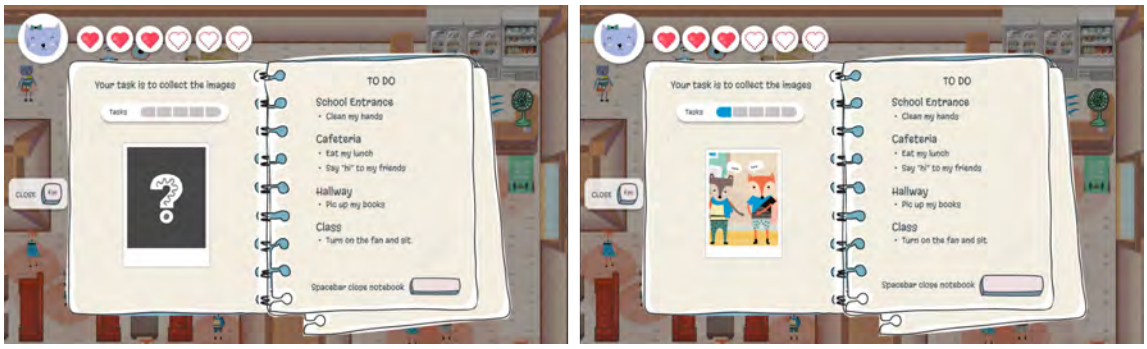

Figure 5.27: Notebook Prototype

Significant Changes within the Prototype

- Quiz Changes
  The quiz's representation of the different risky scenarios (Figure 5.28) changed from a top-down perspective into a much more friendly and understandable first-person view. The players welcomed this update as it made much more sense to see a photo of the event in question.

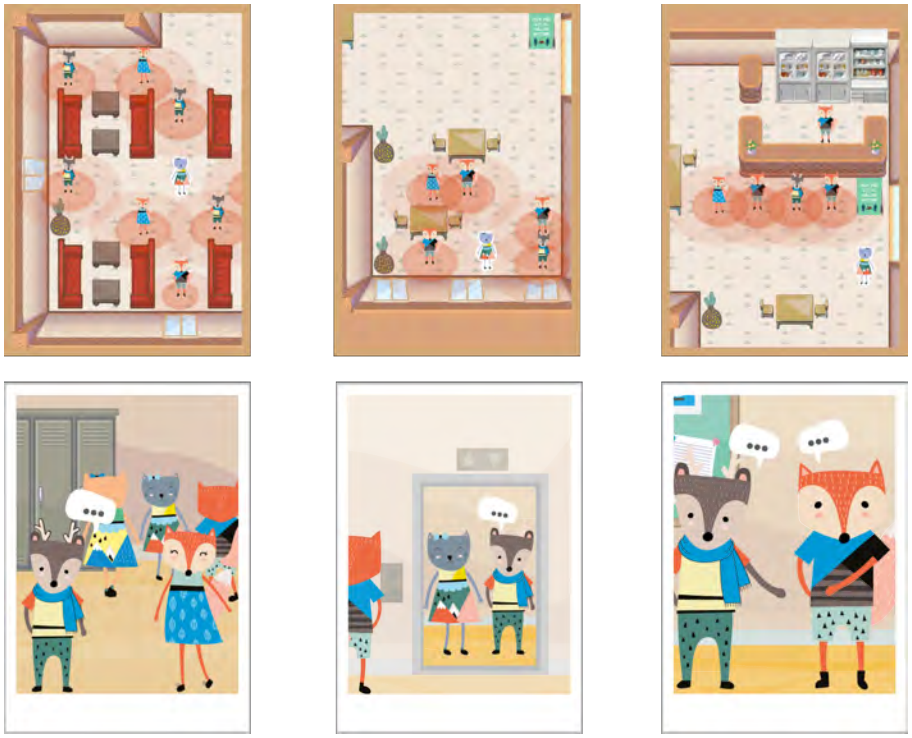

Figure 5.28: Picture Changes - Crowded Place, Closed Space, and Close Contact

- Map Layout
  The map passed through multiple iterations, aesthetically and structurally. The most relevant differences can be observed in Figure 5.29. Furthermore, after receiving feedback in the first evaluation with children, and thanks to the technical possibilities, the team took away the constraints of only working with the cafeteria level, implementing the new two levels directly into the MVP.

Figure 5.29: Evolution of the Cafeteria Level

5.4.4.3 Minimum Viable Product

With every iteration of the high-fidelity prototype, the team worked on implementing the design in code to create a MVP. This approach allows for the testing of advanced game mechanics that a regular prototype doesn't allow. Examples of features evaluated in this manner are the feel of the movement or the difficulty of dodging other people.

Thanks to coding the game in parallel with designing it, every iteration of the prototype brought the final product closer to realization. Feedback about the design was immediately addressed, implemented, and deployed into the live version of the game. This combination of agile software development and the google design sprint created great flexibility, which allowed small changes whenever the design needed testing.

The first set of changes for the MVP came after the formative evaluation with experts. Among other comments, the feedback involved annoyance because the answers on the quiz were ambiguous, and the goal in the game was unclear. Also, the team noticed the players had difficulties with the characters' movements and realized the need for mouse support. At that moment, the prototype still complemented the formative evaluation by showcasing the character selection of the game and end-screens.

When it was time for the first evaluation with children, the MVP could already deliver the complete experience. The feedback on the game was positive, but there were new challenges to address. Thus, the MVP required changes to address the

difficulty of the game and the feedback when the character would receive damage. Furthermore, the team designed a new feature, a notebook that lets the player keep track of the goal.

5.4.5 Validating the Solution

The following section describes how the team proceeded with the validation methods and the procedures performed to evaluate the digital artefact. The evaluation consisted of two phases: a formative evaluation (heuristic evaluation with experts) and a summative evaluation with the target group.

5.4.5.1 Formative Evaluation with Experts

First, the heuristic evaluation involved experts that could provide usability feedback. The team also requested each of these participants to write love letters and breakup letters to express their sentiments towards the digital artefact.

- **Heuristic Evaluation**

  The objective of the heuristic evaluation was to verify the usability of the digital artefact. Moreover, this evaluation also sought to determine if the solution's messages were on the right track to deliver the learning goals.

  The heuristic evaluation consisted of an online meeting through Zoom. The team invited one expert at the time, requesting them to evaluate the usability aspects of the digital artefact. Afterwards, the team told the expert to think aloud throughout the experience, and the team introduced the prototyped screens for the beginning of the game (start-screen and character selection). Then, the expert took control of the MVP, where they could play around at will; while still commenting on the happenings. The team took note of all the comments and feedback addressing interactions, movement, solving quizzes, damage taken, losing/winning the game, and others. Lastly, the team briefly interviewed the expert to ask their opinion on the goal of the digital artefact, how clear the learning goal was, if they felt that they learned something, and three words to describe the digital artefact.

  The heuristic evaluation took place online with three experts in interaction design and one expert in game development. Each session lasted between 30 to 40 minutes.

  Later, the team evaluated the feedback notes and inputs, classifying them according to the ten best practices for usability. The analysis resulted in a document with four distinct labels: statements that reaffirmed the digital solution's goal, statements that were already addressed or solved, statements that required immediate action, and statements that the team left out for being out of scope or due constraints (Figure 5.30).

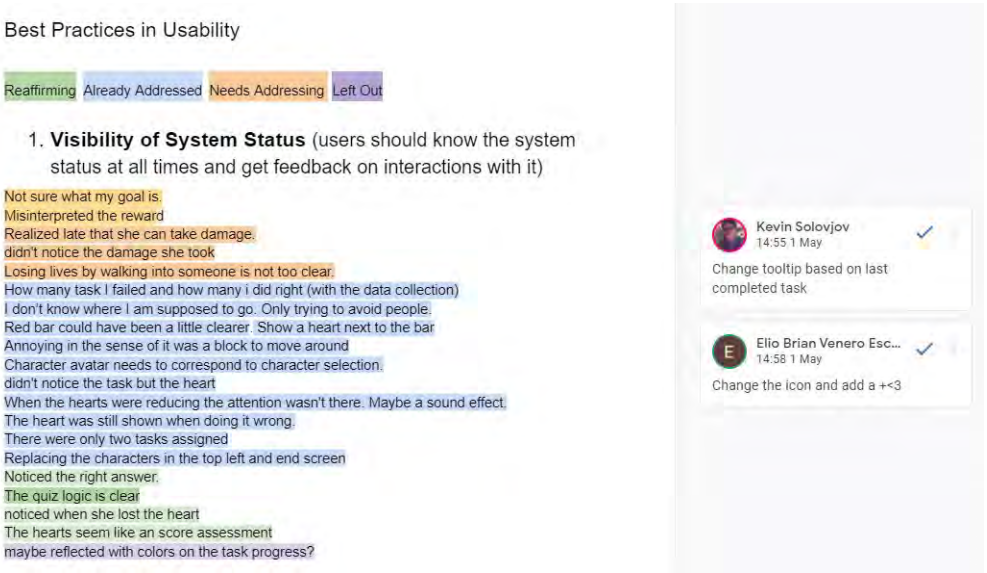

Figure 5.30: Analysis of the Heuristic Evaluation

The feedback received during this evaluation turned into many valuable improvements towards the look and feel of the game, the consideration of redundancy of interactions (adding mouse support). Moreover, the experts validated the learning goals within the experience; while also providing a better understanding of where the game was not very successful delivering them.

- **Love Letter/ Breakup Letter**
  The goal of this method was to gather subjective descriptions and sentiments towards the digital artefact. The team requested the experts to write both a love letter and a breakup letter; after they have experienced and played the game a couple of times. The process of writing the letters, and submitting the online form, took each expert between 15 to 20 minutes. The team collected eight letters that then were further analyzed.

  While analysing the results, the team classified the expert's comments into different categories that addressed the positive and negative sides of the digital artefact. In total, ten categories were identified and then labelled as aesthetics, comfort, content, social distancing, relatable, difficulty, subtle message, interactions, sounds, and instructions. Figure 5.31 shows some of the resulting themes after analysis. It is worth noting that some of the comments were strongly critical of the game features, an attitude that wasn't very evident during the valuation.

  Among the expert's most relevant inputs, we found that the difficulty was perceived as unforgiving when causing damage but not very challenging in terms of complexity. Experts had strong arguments seeming about the lack of content, repetitiveness of gameplay, and obtrusive instructions.
  On the other hand, the experts' comments validated the learning goal by

addressing the value of social distancing, relatability, and subtleness of the message.

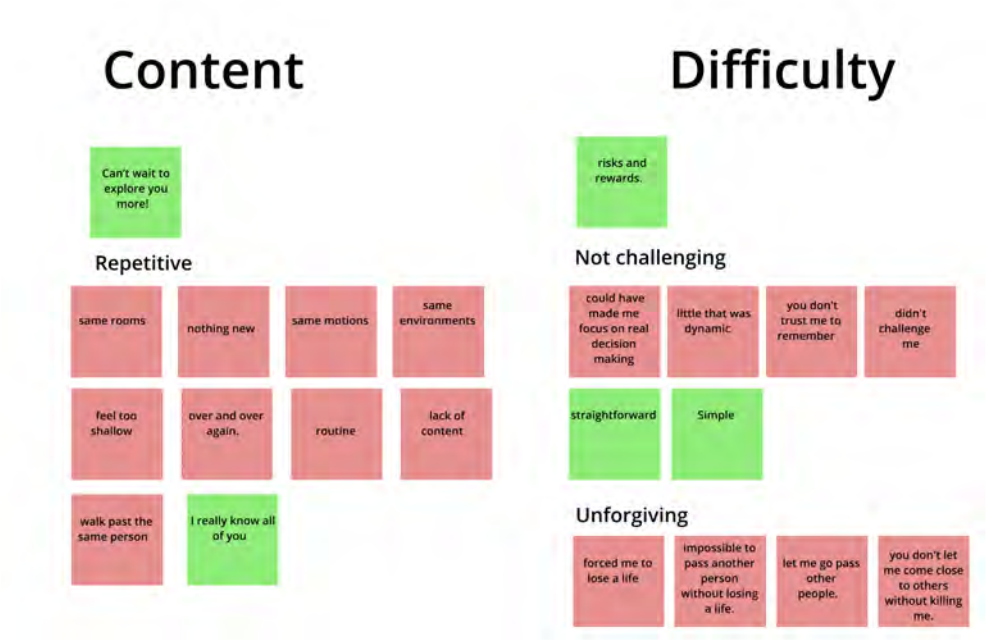

Figure 5.31: Analysis of the Love Letter and Breakup Letter

5.4.5.2 Summative Evaluation with Children

The team carried out two evaluation periods with the target group, ten children between 9-12 years old from Peru and Sweden. Each evaluation period aimed to have five individual participants. The team set three different evaluation methods and four goals within all evaluations. The first goal for each evaluation was to validate the learning goals through the gaming experience. Second, assess the emotional responses from each participant. Third, validate the usability of the interactive digital artefact. And, lastly, note the participants' self-assessment and reflection comments.

The following methods were used to gather the evidence:

- ***Smilyometer***
  The *smilyometer* covered the second goal for evaluation: assessment of the emotional responses. The team asked the participant to assess their sentiments using the smiley face scale 5.32 after specific events occurred.

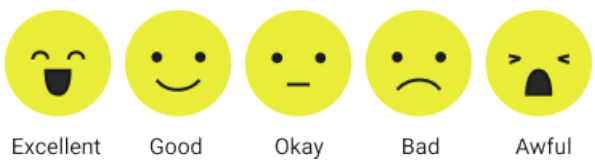

Figure 5.32: Smileyometer - Scale for Emotional Assessment

The assessment of the emotional responses occurred in key moments of the interaction with the digital artefact. For instance, each participant was asked questions phrased as: "how did you feel about...?" and "how does ... make you feel?". The list of questions is in the following table:

SM	Emotional Assessment Questions - Smileyometer
SM1	How does the pandemic make you feel?
SM2	How did the character selection make you feel?
SM3	How did the tutorial make you feel?
SM4	How do you feel after solving the quiz?
SM5	How do you feel about the losing screen?
SM6	How do you feel about the winning screen?
SM7	In general, how do you feel about the game?

Table 5.1: Emotional Assessment Questions - Smileyometer

For each question in Table 5.1, the team requested the participant to mark their answer in an online form. The whole assessment process took place during each participant's first playthrough.

- **Remote Moderated Research**
  The remote moderated research strictly followed the usability checklist method with the think-aloud protocol. The goal for this method was to assess the learning goal throughout the game and verify the usability. For instance, after children had access to the video game, they had to share the screen with the researchers to evaluate their performance in the game. The team also requested the child to think aloud and be vocal while playing the game.

The usability checklist consisted of the following items:

UC	Usability Checklist for Remote Moderated Research
UC1	If the player understands the task but can not complete it within a reasonable amount of time.
UC2	If the player understands the goal but has to try different approaches to complete the task.
UC3	If the player gives up.
UC4	If the player completes a task but not the specified one.
UC5	If the player expresses surprise or delight.
UC6	If the player expresses frustration, confusion, or self-blame.
UC7	If the player points out things that are not right or that do not make sense.
UC8	If the player makes suggestions for the interface or flow of the game.

Table 5.2: Usability Checklist for Remote Moderated Research

The team constantly took notes over the actions and comments of the player that fit into the learning goals or the usability checklist. It is worth noting that

the usability checklist items *UC5* (if the player expresses surprise or delight) and *UC6* (if the player expresses frustration, confusion, or self-blame) were mostly addressed by the Smileyometer. Lastly, the participant was allowed to try and play the game again until they felt done. This process gave the team a chance to ask further questions in their subsequent attempts when the smileyometer was not a requirement anymore.

- **Interviews**
  The interview aimed to assess the participant's self-assessment and reflection on the game. It consisted of a few questions to gather the last comments and inputs, as seen in Table 5.3:

IN	Interview Questions Post-Interaction
IN1	Would you want to play the game again?
IN2	What are three words to describe the game?
IN3	Is there anything new that you have learned while playing?
IN4	What are some behaviours that can be applied in the real world?
IN5	What video games do you usually play with your friends?
IN6	What do you think about the name of the game?

Table 5.3: Interview Questions Post-Interaction

The first question aimed to learn how many times could the participant voluntarily try the game again until they felt done. The second question required the children to sum up the game with three words. The following two questions addressed the self-assessment and reflection on the learning goals. Finally, the last two questions tried to gather inputs about other video game titles and feedback about the current game title.

These three methods were organized within one online play test session (Zoom.com) to which the children were invited individually. First, the team shared a presentation with the participant to explain the whole process and thank them for their cooperation. Then, two links were provided so the participant could access the MVP and the emotional assessment form. The participant shared their screen and one of the team members took control of their screen only to quickly switch tabs when the emotional assessment was in order. Overall, ten evaluations have been performed, each taking between 15 to 20 minutes. Eight of them with Swedish children and two with a Peruvian children. Five evaluations were carried out in Swedish, three in English and two in Spanish.

The first round of five evaluations were very successful and provided valuable feedback on the game's usability. Besides following the same evaluation process, the second round of evaluations validated if the new notebook feature made the learning goals clearer by stating it as "collect the photos!". This last evaluation process also sought to figure if the game's difficulty was not as unforgiving as before.

5.4.5.3 Data collection

The game collects anonymous data about various user actions, which the team will use to complement the qualitative findings. The most valuable of these data points is the length and score of an entire playthrough. This metric includes playthroughs where the player loses, which the game marks with a score of "0". This data should allow the team to gather exact quantitative results, such as the average time it takes to play the game and whether it meets expectations to adjust the difficulty.
Besides the overall results of a playthrough, the game also registers minute interactions. Currently, this is limited to the quizzes, where the game saves the time to complete the quiz and whether the user got it right on the first try. The additional data helps to recognize which quizzes might have confusing illustrations and need simplifying, or just if they meet the desired difficulty.

5.4.6 Results from Summative Evaluations

5.4.6.1 Smileyometer

The smileyometer gathered the the participant's emotional perception. These inputs also tackled the usability checklist items *UC5* (if the player expresses surprise or delight) and *UC6* (if the player expresses frustration). The following four questions evaluated the experience:

- **SM1 - How does the pandemic make you feel?**

  The smileyometer confirmed the hypothesis that children felt frustrated with the pandemic's restrictions. Out of ten children, the average sentiment was "bad". Where two children perceived it as "awful" and another two as "okay".

- **SM5 - How did you feel about the losing screen?**

  The smileyometer showed that the losing screen had very mixed responses. The team perceived that some children didn't address the losing screen itself but the feeling of losing. Between the ten children, the overall sentiment was "good".

- **SM6 - How did you feel about the winning screen?**

  The smileyometer showed that, although only three children arrived at the winning screen, two of the responses were "excellent" and one "good".

- **SM7 - In general, how did the game make you feel?**

  The smileyometer suggests that children were very satisfied with the game. Out of ten, four children felt "excellent", five felt "good", and one child felt "okay".

5.4.6.2 Remote Moderated Research

The *remote moderated research*, through the usability checklist (UC), gathered inputs related to the usability of the digital artefact and the experience in general. Results from items *UC1* and *UC2* were presented previously; consequently, the remaining items follow:

- **UC3 - If the player gives up**

  The team noticed that children gave up after failing two or three attempts. All five participants from the first round of evaluation gave up due to the difficulty of moving around other characters. Nevertheless, during the second round of evaluations, the team observed that two children gave up after trying three and four times, respectively. The remaining three children managed to win the game.

- **UC5 - If the player expresses surprise or delight**

  The team assessed that children were delighted with the game. Children used the following words to describe the game: "cute art style", "happy colours", and "helpful". Moreover, the smileyometer (SM7) shows that children felt "good" about the game on average, even after losing in many cases.

- **UC6 - If the player expresses frustration, confusion, or self-blame**

  In the first round of evaluations, the children expressed some confusion due to an unclear goal for the game. Likewise, the team observed that children were less confused in the second evaluation round, thanks to the notebook feature. Nevertheless, some children still had a difficult time figuring out where to find the missing tasks.
  The team observed that even though children lost the game, their frustration was not big enough to ruin their experience. Moreover, children appreciated the initial unforgiving difficulty of the game, commenting that it was a "hard" but "fun" experience. The smileyometer (SM7) also corroborated the "good" experience.
  While children played, the team noticed Peruvian children had a hard time recognizing the Spanish flag as a symbol of the Spanish language. Similarly, the team perceived some confusion when Swedish children encountered the word "crowded" translated to Swedish as "trångt".

- **UC7 - If the player points out things that are not right or that do not make sense**

  In the first round of evaluations, when solving the first task at the cafeteria level, children confused the solution of a quiz because the picture was ambiguous. The team also took note of their comments when children thought they

could take hand sanitiser with them.

- **UC8 - If the player makes suggestions for the interface or flow of the game**

  Children suggested adding "more characters" and "unique powers". A child wanted to have more interactive things "to pick up", and some requested "more exploration".

5.4.6.3 Interview Post-Interaction

The Interview Post-Interaction sought to complement the findings by asking a set of closing questions to the participants. The results from the items *IN3* (Is there anything new that you have learned while playing?) and *IN4* (What are some behaviours that can be applied in the real world?) have already been presented within the *Stage 2 - Assessment Evidence*. The remaining items of the interview consist of:

- **IN1 - Would you want to play the game again?**

  Every time they finish a game, the team asked the child if they wanted to play the game again or if they felt done (regardless of losing or winning). Every single child played the game at least twice, including the child that won the game on the first attempt.

- **IN2 - What are three words to describe the game?**

  When describing the game in three words, children mentioned: "hard", "challenging", "confusing", "obstacles", "to think", "think hard", "fun", "positive feeling", "Corona", "pandemic", "close", "clear", "simple instructions", "relatable", "teaches", "helpful" "take precautions", "help to recognize danger", "happy colors", "cute", and "arstyle".

- **IN5 - What video games do you usually play with your friends?**

  Among the games they played, children mentioned: "car games", "Animal Crossing", "FIFA", "Fortnite", "Warzone", "Roblox", "Zelda", "Mario Kart", and "Super Smash Bros."

- **IN6 - What do you think about the name of the game?**

  The team noticed that children didn't have strong opinions about the game's name in any language localization. Children commented that the name was "good" and "creative" in their respective language.

5.4.6.4 User Performance

The game collected data automatically per the specifications described in the previous chapter. The MongoDB database logged user performance, tracking the score and length of each playthrough and their results from the quizzes. MongoDB provides a tool for visualizing and analyzing database entries, which the team has used to understand the gathered data through graphs and calculations, as seen in Figure 5.33.

The team provided the links to schools and families with children, encouraging them to try the game. The numbers reflect a substantial amount of playthroughs, but since the data is anonymous, the team cannot guarantee that only children have played the game. The results were still deemed to be valuable by the team as long as a healthy amount of skepticism was applied during analysis. The results have been compiled in two tables to give a better overview of the findings. The game results can be found in table 5.4 and the quiz results in table 5.5.

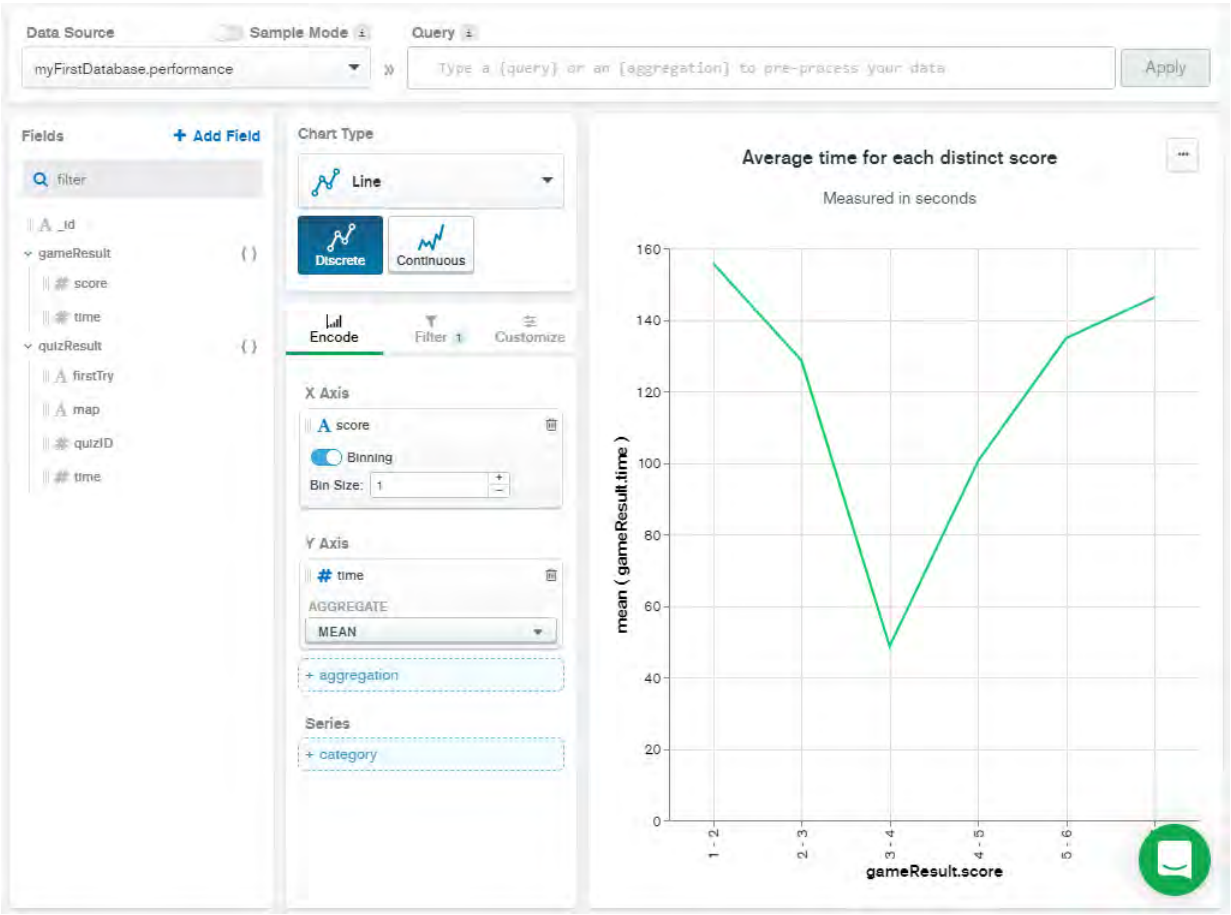

Figure 5.33: MongoDB chart over average completion time of winning games per distinct score

Recorded user performance on finished games		
Playthroughs	Avg. Time (Minutes)	Finished
All	1.5	119
Wins	2.0	37
Losses	1.4	82

Table 5.4: Collected data on playthroughs, including wins and losses.

Recorded user performance on quizzes			
Quiz Name	Avg. Time (Seconds)	Attempts	First try
Hand Sanitizer	2.8	159	138
Eat Lunch	2.2	72	64
Greet Friends	2.7	91	64
Elevator	1.6	48	40
Classroom Window	6.1	35	23

Table 5.5: Collected quiz data

6

Results

This chapter shows the results of the *research through design* process. The results are divided into two main categories, the digital artefact or *Pawdemic*, and guidelines. These categories mainly intended to present the results that later will be discussed to answer the research questions of this master's thesis, such as the first one:

How suitable is the Rich Experiences framework to leverage negative emotions when introducing potentially frightening topics toyoung children?

Moreover, Pawdemic showcases what a product developed according to the team's design process could look and behave. The research and findings involved in the design of Pawdemic will culminate in the final section, which lists guidelines that address the second research question:

What are some possible considerations when creating an engaginglearning experience through an interactive digital artefact for children?

The chapter, as a whole, should provide satisfactory evidence to answer the research questions by offering a holistic exploration of the design process involving children, the difficulties encountered and the resulting design.

6.1 Pawdemic

This section describes the digital artefact in terms of design and technical specifications. The digital artefact, named *Pawdemic* in English, has a target audience of children between the ages of 9-12 years old. This friendly and cute-looking game presents the challenge of staying safe at school.

The first part focuses on the design and explains how and why the artefact looks and behaves in a certain way. The second part details the creation of Pawdemic through programming and the technologies that have made it possible.

6.1.1 The Game

This section will present and explain the happenings within a playthrough of the game. The subsections will describe significant parts of the game in order of appearance in a playthrough, including the team's reasoning behind the design.

6.1.1.1 Start of game

After choosing a language, the game shows the title screen. The start of the game is supposed to set up expectations for minimalist aesthetics. The whimsical background music starts on this screen accompanied by the first UI elements. The title consists of a localized pun or rhyme with the word 'pandemic' and an icon of a cartoon fox. The title is smoothly animated and there is a stylized button prompting to press the space key to begin the game. The entire bright cartoon aesthetic with simple colors and happy music should evoke feelings of positivity.

Figure 6.1: Title Screen in English (Paw-Demic)

Following the title-screen is a character selection screen, where the user may choose their digital avatar (fig 6.2). The available characters are anthropomorphic animals, which was a conscious decision to reduce feelings of racial and cultural exclusion. The idea was that since the user chooses an avatar of another species that isn't human, skin color and racial bias wouldn't factor in their choice. The current selection of characters is between a male-coded fox and a female-coded cat.

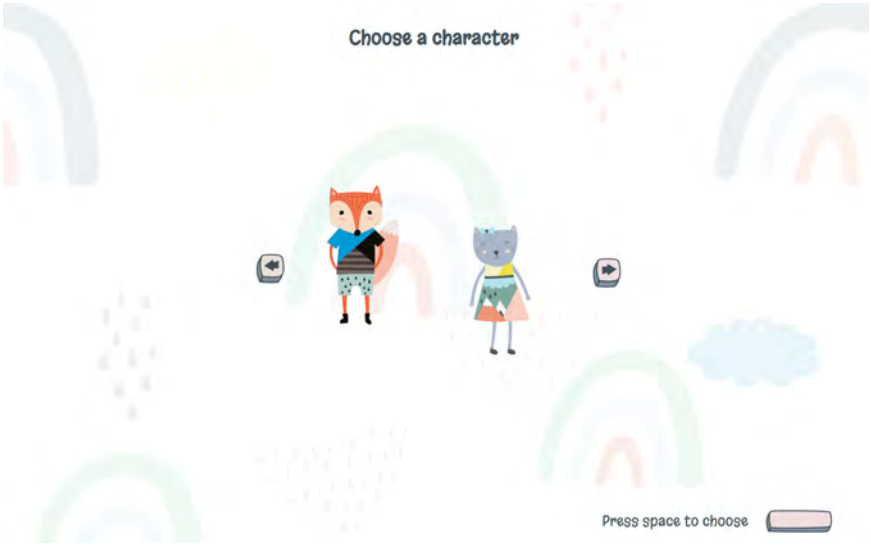

Figure 6.2: Character selection screen, the fox is highlighted.

After choosing a character, there is a short loading screen after which the first level loads, with the language and character set based on the user's choices.

6.1.1.2 Tutorial

After the user has chosen an avatar and the game has loaded, they will see the tutorial level (Fig 6.3). The tutorial level works the same way as all other levels in the game but is simply much smaller and straightforward. It consists of a small room with a single task and a single non-player character (NPC). The purpose of this level is to introduce the game mechanics without being overwhelming.

One thing unique to the tutorial level is the pop-up that explains controls on the bottom side of the screen. There is an explanation for the movement, interaction, and a warning to avoid other people. The images in the pop-up are very descriptive so that younger users that have trouble reading should still be able to understand them. The explanations also cycle every 2 seconds, highlighting different parts to draw attention to each one individually. This pop-up remains until the player leaves the tutorial area but hides behind any other prompted windows.

Once the user has acquainted themselves with the UI, there are two items of interest in the room. One of these is a bottle of hand sanitizer with a blue tile next to it, and the other is a character (NPC) surrounded by a red circular area. The intended flow of the tutorial is for the user to briefly get used to the controls and wander onto the blue tile, which will prompt them to press the space key to interact. Upon interaction, the user opens the first quiz in the game. The quiz has been made intentionally easy and ultimately serves to assess the learning goals. The quiz mechanics and UI are the same with all of the interactive elements.

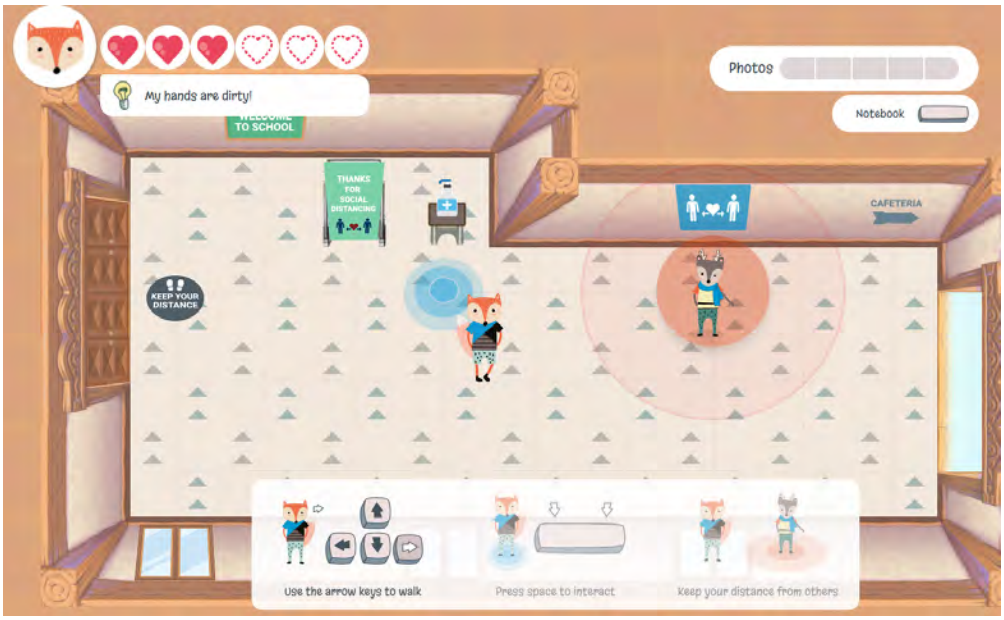

Figure 6.3: Screenshot of the tutorial level. The tutorial is currently highlighting the arrow keys

After completing the quiz, the user should move onto the next room. An NPC stands in the way, and if the user walks into the NPC, they will immediately lose a life point. If the user stands near the NPC without colliding with them, the user will see a timer that will take a life point from them if they wait too long. The purpose of this NPC is to introduce the damage and avoidance mechanics. Keeping their distance while passing the NPC allows the player to walk through the door and leave the tutorial.

6.1.1.3 Movement and danger

A core mechanic of the game is the avoidance of other people. This part of the game is supposed to reinforce social distancing in the players' minds. Avoiding people is not the main goal of the game, but it is something that the players need to keep in mind if they want to complete their tasks, much like how they have to remember to keep their distance from people in real life during a pandemic even if they wish to do something else.

Unlike real life, it is easy to see when the player is too close to someone in the game. The game warns the player of danger using transparent red circles around the NPC characters, which become darker and more opaque closer to the NPC. The team wanted to incorporate the idea that it's not just about distance but also time spent close to another person. The outer zone doesn't immediately damage the player but starts a timer over their head, telling them how long they can stay in the danger zone (Fig 6.4). The color change should show that the inner circle is even more dangerous. Colliding directly with an NPC character will make the player lose a life immediately, signifying that they went even further against the principle of social distancing.

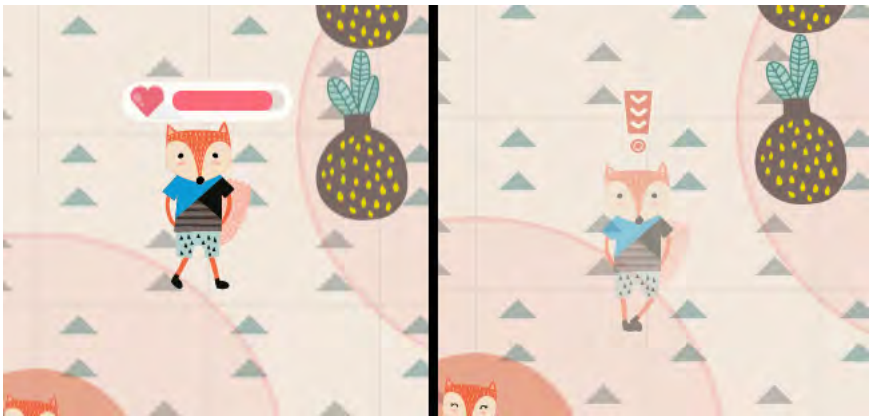

Figure 6.4: Left: Danger timer, Right: Indicator after taking damage & character fading

After taking damage, either by colliding with an NPC or waiting out the timer, the player enters a temporary phase that protects them from further damage. The game shows this phase of invincibility by making the character fade in and out rapidly as well as playing a sound. This animation includes an exclamation mark appearing above the player character's head to reinforce that something important has happened.

6.1.1.4 Goal of the game

The goal of the game is to collect photos scattered around the school. The players receive a photo for every quiz they complete, with the photo being the same as the picture asked about in the corresponding quiz. This goal forces the player to explore the levels looking for all the photos to complete the game. The photos found can always be found on a blue interactable tile. The blue tiles make the photos stand out and create a recognizable symbol even when the object the player interacts with changes.

The game provides the player with a notebook (Fig 6.5) to aid in finding and keeping track of the tasks. The left page shows an overview of how many photos have been collected and reiterates that the player needs to find them. Below the progress bar are images of the photos in the current room, which start blacked out until the user completes the corresponding quiz. The right page contains a laundry list of the tasks in the room and crosses them out when the player completes them. The purpose of the list is to give a verbal clue as to what items are of interest.

6.1.1.5 Quizzes

To collect photos and win the game, the player must complete a certain amount of quizzes. These quizzes are triggered by standing on a blue interactable tile and pressing the spacebar or clicking the prompt. The quiz has an interface similar to the notebook since the notebook is where the player keeps the photos they get from the quizzes.

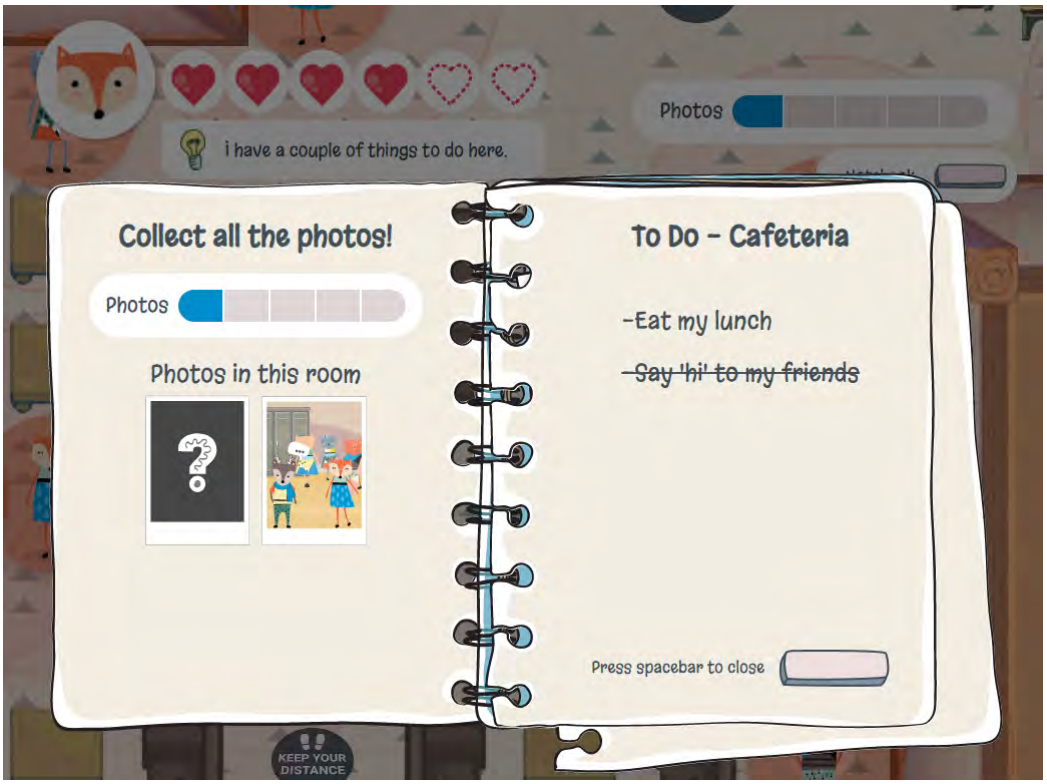

Figure 6.5: Notebook for the cafeteria, one task complete

The left page of the quiz shows a potential reward and a large photo of a situation transpiring in the school that somehow breaks social distancing. The player's task is to identify how exactly the scenario in the photo goes against social distancing by choosing one of the options on the right. The options are the three C's: closed, crowded, and enclosed. The player can choose by clicking the options or navigating with the arrow keys and confirming their choice with the spacebar.

The player receives the photo whether they chose right or wrong, but there is a secondary reward to incentivize correct answers in the form of life points. If a player chooses the correct answer on their first guess, the chosen option turns green, and the photo changes to a message of praise informing the player that they have received a life point with a happy melody playing in the background. If the player chooses incorrectly, the game plays an error sound, and the chosen option turns red before the player is allowed to guess again.

After a player has guessed incorrectly once, the heart icon over the photo fades away to signify that the reward is gone before letting the player choose again. On their second choice, the player either guesses incorrectly and is given the answer or guesses correctly and receives praise. Either way, the message informs the player that they have missed the heart in this quiz.

Figure 6.6: The first quiz in the tutorial level

6.1.1.6 Losing

When the player runs out of lives, they lose the game and see the losing screen. There are three main features on the losing screen: A large text saying "You were sent home!", an animation of a heart fading away into an outline, and the player character lying in bed. The text is there to explain what just happened, that your character has been sent home, either because they got sick or maybe for not following rules.

The fading heart is supposed to be the last life point that the player lost and that it is the loss of this life point that led them to this screen. The team wanted to specifically avoid using terms like "You died" or "You lost" and instead find a phrase that fits better thematically and doesn't evoke an equally negative response. Finally, the character in the bed is supposed to show that even if you sick, your player character is not dead and merely needs to rest in bed a while

6.1.1.7 Winning

If the player succeeds in finding all of the photos, the game will end, and the game displays the winning screen. The winning screen congratulates the player on staying safe and shows their score. The score depends on the player's remaining life points. The decision to use life points for scoring made sense to the team since the player receives life points for correctly answering quizzes and loses them by staying too close to NPCs, so the life count by the end can be a measure of the player's overall performance.

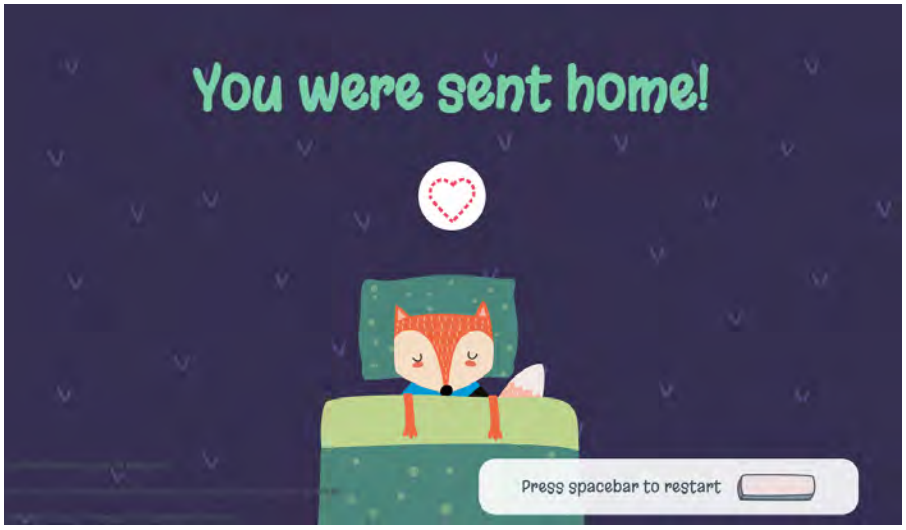

Figure 6.7: Game over screen

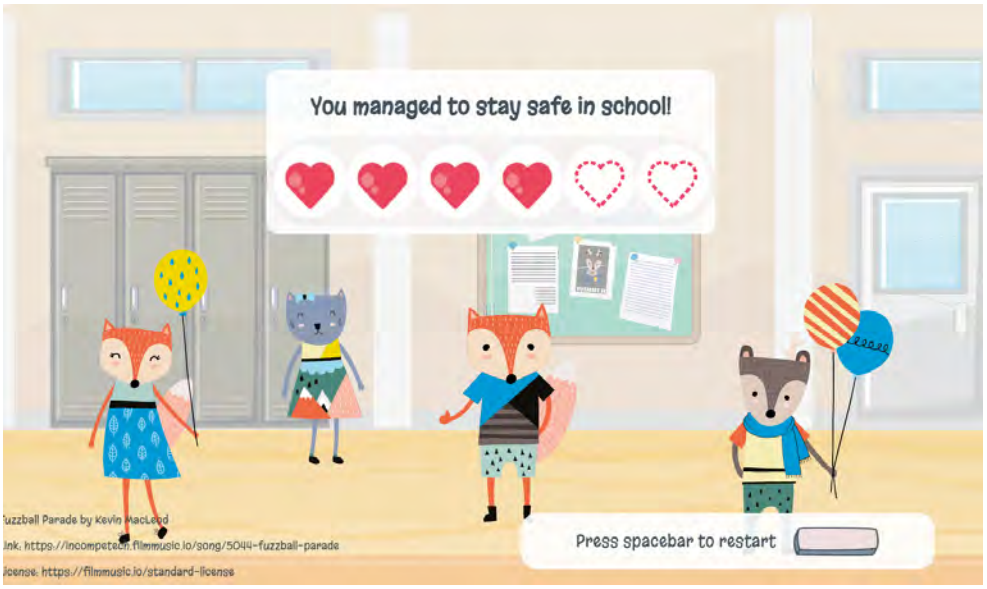

Figure 6.8: Victory screen

Besides the score, the winning screen shows a celebration between the player character and their friends. The team found that one of the things that children missed most from before the Covid-19 pandemic was hanging out with their friends. The game shows friends coming together as part of the victory to show the player how following rules could help things return to normal.

6.1.1.8 Other considerations

The team initially intended to only deliver the experience in Swedish, but the difficulties in finding local participants in the participatory design process challenged

the team with finding users abroad. From the team's experience, most children are only fluent in a single language at the age of 9-12, and those that have some ability to speak a second language still prefer to use their native tongue. Therefore, the game was also localized in English and Spanish so that the foreign participants testing the game would receive an authentic experience, which had the side effect of making the game more accessible. The game therefore begins by presenting the user with a choice of language through three images of flags, Swedish, English, and Spanish (Fig 6.9).

Figure 6.9: Left: Language selection, Right: Loading screen

Another important consideration was input redundancy. The game initially only allowed keyboard input, but that quickly changed as the team noticed players reaching for the mouse. The game now allows both mouse and keyboard input for most of the interactions besides the movement. This redundancy lets less computer literate users try whatever input methods feel natural to them and still get results.

Finally, a minor yet valuable change was the look of the loading screen (Fig 6.9). The game required time to load during interactions, especially in the beginning and when changing levels. The previous loading screen consisted of fading to black and fading in the new level without bringing too much attention to the loading process. The team felt that these loading times broke up the experience and could take the user out of the flow. The loading screen was then changed to a bright screen following the same theme as the start of the game, with a text that says "loading" and an animated turtle. This loading screen serves mainly to distract the user from the fact that they're waiting by showing them something new, but also gives the user feedback that the game is working on something by telling the player why they're waiting and using the turtle animation to show that the game has not frozen or crashed. The turtle also primes the user to expect something slow and makes them more likely to give the loading screen some time.

6.1.2 App

The vast majority of the game was made using Javascript, specifically using the library React.js. The use of pure React.js without any other game engine or rendering library like canvas is somewhat novel, and the team had to consult the few other instances of this approach to get started, notably, an open-source project called "React RPG". The choice to only use react for a game of this scope was made since the team had significantly more experience with web development than game developments, and felt that it would be easier to make a game within the framework of HTML, CSS, and Javascript than learning a new language or library within the time of this project.

Besides React.js there is a complementary library called Redux which helps with state management in React.js. The team expected state management to be problematic with a react application this complex, and the inclusion of Redux managed to save a lot of time on making different parts of the game communicate.

Finally, there is a small back-end built with the javascript runtime node.js. This back-end also includes a framework called Meteor which exists to simplify setup, deployment, and database management for node.js applications and setup of MongoDB databases. The back-end was intended to handle multiplayer features and online play, but those aspects were scrapped during development and the back-end was repurposed for data collection. Using Meteor also simplified the deployment of the app, as the team could easily upload the game to Meteor's hosting service called "Galaxy" with very little setup.

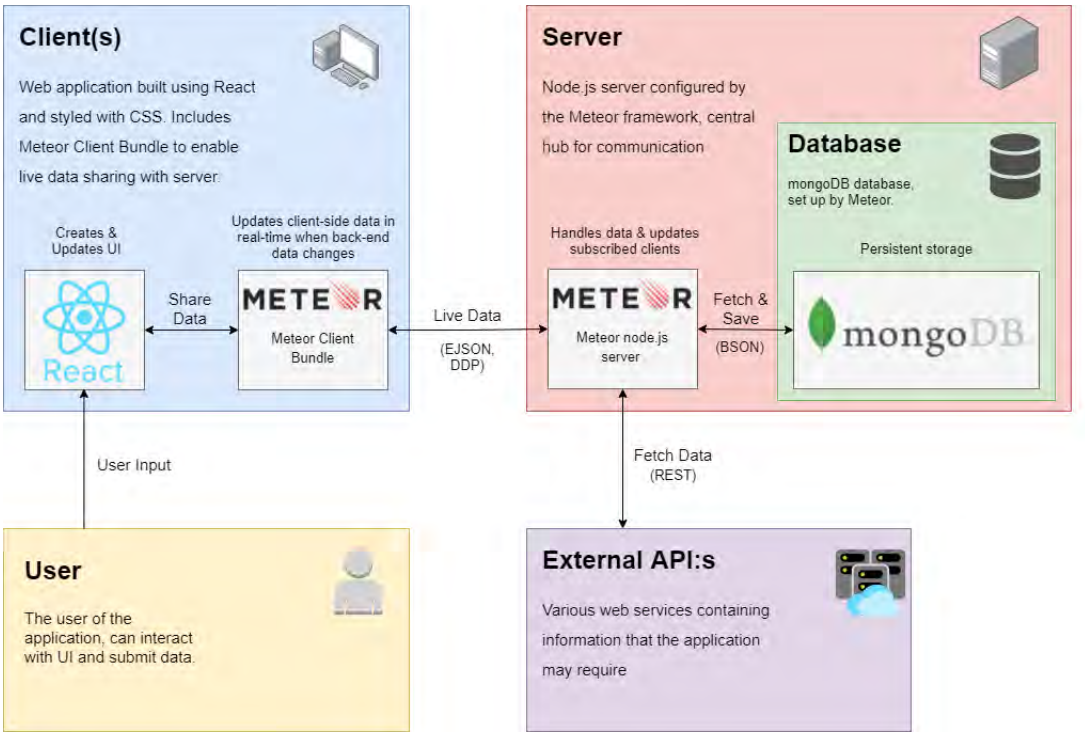

Figure 6.10: The software architecture

6.2 Backward Design

The following section presents the results from the different stages of the *backward design*. In each stage, the team assessed the learning goals within the game experience.

6.2.0.1 Stage 1 - Desired Results

The *Stage 1 - Desired Results* of the *backward design* had the selection and description of a learning subject. As a result, the team set the learning goals for the experience as clearly as possible; as previously shown in Chapter 5.4.1.4, Figure 5.10 - *Stage 1 - Desired Results*.

- **General Learning Goal**
  Players will understand essential concepts about social distancing and the spread and prevention of COVID-19.

  The team also considered enhancing learning experiences using the *rich experiences framework* to create what they called *Rich learning experiences*, and how this approach could help educational material to leave a lasting impact on learners.

- **Specific Learning Goal**
  Players will use an understanding of the "Three Cs" of social distancing: Close contact, Crowded places, and Closed spaces.

Moreover, in consideration of the children's sentiment of frustration towards the pandemic, the *three Cs* characterized a subject that could not only be relatable but very much useful and impactful.

6.2.0.2 Stage 2 - Assessment Evidence

The *Stage 2 - Assessment Evidence* of the *backward design* had the Figure 5.14 in Chapter 5.4.3.2 as a partial result. Within it, three major categories for assessment of the learning goals were introduced: "E. What evidence will show that players understand", "F. Other evidence to be collected", and "G. Player self-assessment and reflection". In the following paragraphs, the team will present each category and address their results:

E. What evidence will show that players understand

Table 6.1 lists the statements in evaluation. Each statement will be addressed in terms of the results from the last phase of the design process, Validation. This in-

cludes learning-goal related results from the methods: Remote Moderated Research, Smileyometer, and Interview Post-Interaction.

	E. What Evidence Will Show that Players Understand
1	Understood the avoiding mechanic
2	Avoided spending too much time too close to others
3	Solved quizzes with close contact, closed spaces and crowded places
4	Lost the game - learned a valuable lesson on safety and social distancing
5	Won the game - understood the tasks, mechanics, and challenges

Table 6.1: Stage 2 - Evidence of Understanding

- *1. Understood the avoiding mechanic*
  Within the remote moderate research method (UC), the team validated that children actively avoided other characters. Some children took damage before realizing the consequence was losing a life/heart.

- *2. Avoided spending too much time too close to others*
  Within the remote moderate research method (UC), the team validated that children quickly understood that staying too close to other characters could be dangerous.

- *3. Solved quizzes with close contact, closed spaces and crowded places*
  Within the remote moderated research (UC4), the team validated that children understood the logic behind the quiz. Likewise, while some children didn't solve the quizzes flawlessly, they still managed to select the correct answer.
  Nevertheless, few children arrived at the fourth and fifth quizzes. In this scenario, the fourth quiz was solved correctly by the four children who got there. Only three children arrived at the last quiz, and from them, one failed the quiz, and two answered correctly. It was also evident that children took longer to assess the fifth quiz (enclosed scenario).
  On the other hand, when evaluating the quiz sentiment, the smileyometer (SM4) showed that after solving quizzes three times, three children felt "excellent", five felt "good", one felt "okay", and one didn't manage to fill-up the form.

- *4. Lost the game - learned a valuable lesson on safety and social distancing*
  Within the remote moderated research method (UC), the team noticed that all but one child lost the game on their first attempt. One child commented "I'm not as mad as usual after losing".
  The smileyometer (SM5) showed that, on average, children felt "okay" with losing the game. One felt "awful", and one felt "good".
  Within the Interview Post-Interaction (IN2), children pointed out keywords to describe the game like "take precautions", "to think", "relatable", "teaches", "recognize danger", "pandemic", and "corona".

- *5. Won the game - understood the tasks, mechanics, and challenges*
  Within the remote moderated research method (UC), the team noticed that the game's difficulty did not let the children in the first evaluation group win the game. Meanwhile, in the second evaluation group, three out of four children managed to win the game. Two children lost the game at least once, and one of them won the game on the first attempt.
  The smileyometer (SM6) showed that two children felt "excellent" about winning, and one felt "good".
  Within the Interview Post-Interaction (IN2), children pointed out keywords to describe the game like "challenging", "simple instructions", "helpful", "fun", and "positive feeling".

F. Other Evidence to be Collected

Other evidence collected with the smileyometer included children's perception of the character selection screen (SM2) and the tutorial level (SM3). This complemented the usability checklist items that seek to discover the participants expressions of frustration, delight, confusion or self-blame (UC5 and UC6).

- **SM2 - How did you feel about the character selection?**

  The smileyometer showed that two children felt "excellent" about it, six children felt "good", and two felt "okay". On average, the character selection made the children feel "good".

- **SM3 - How did the tutorial make you feel?**

  The smileyometer showed that the tutorial made eight children felt "good" and two "okay". On average, the this game level made the children feel "good". It's worth noting that some children took much longer than others to understand the tutorial level.

Other learning-goal related evidence collected by the remote moderated research included the ability to understand the tasks and the goal within Pawdemic. Other findings from this method are described further ahead, within its particular section in results "Remote Moderated Research".

- **UC1 - If understands the task but can't complete it within a reasonable amount of time**

  Within the remote moderated research, the team could assess that children understood the tasks at hand. Children didn't have any issue solving the quizzes; Nevertheless, children had issues realizing the implications of solving a task correctly or incorrectly.

- **UC2 - If understands the goal, but has to try different approaches to complete the task**

  Within the remote moderated research, the team noticed that the notebook was a great improvement for children to understand the goal of the game. Nevertheless, some children took a long time to understand the usefulness of the notebook and spent some time not knowing what do to, where to go, or going back to other areas in confusion (UC6).

G. Player Self-Assessment and Reflection

The players self-assessment was addressed by a set of questions in the Interview Post-Interaction (IN):

- *IN3 - While playing, have you learned anything new?*
  The team validated the self-assessment of the learning goal. Answers like *"if you are too closed or [it's] too crowded, [the] virus might spread or you might get sick."*, and *"[...]it's important to keep distance"* led to this understanding. Another child commented that that "people's life could be in danger if they get too close to others". Lastly, two children also pointed out that they have not learned anything specifically new *"just to keep social distancing"*.

- *IN4 - What are some behaviors that can be applied in the real world?*
  Children inferred that the game talked about the COVID-19 pandemic by describing it with words like *"Corona"* and *"pandemic"*. Moreover, after reflection, children answered this question with comments like *"Absolutely, [you] need to keep the distance from people so you won't get sick"*, *"Respect the social distancing. [And] wash hands."*, *"Keep the distance to stay safe"*. Lastly, one child explained that she could make use of the lessons learned when going to the mall to avoid being too close to others.

6.2.0.3 Stage 3 - Plan Learning Experience

The *Stage 3 - Plan Learning Experience* resulted in a storyboard detailing the learning activities. It can be seen in Chapter 5.4.3.3, Figures 5.18 and 5.19 - storyboard scenes.

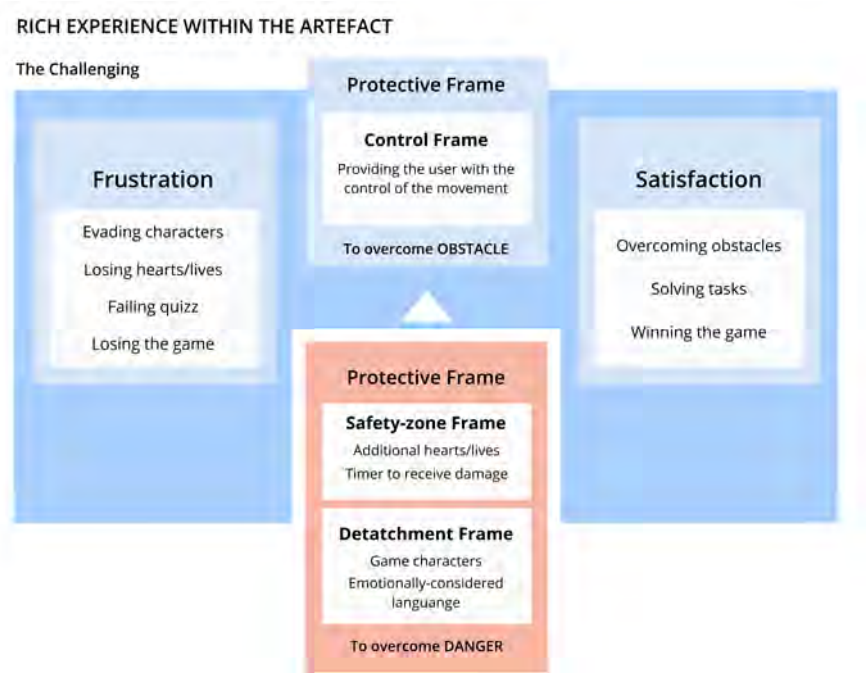

Figure 6.11: Resulting Rich Experience within the Digital Artefact

6.3 Rich Experiences

The result of the *rich experiences* framework within Pawdemic is present in the Figure 6.11. It was a design decision to avoid using "frightening" emotions, as the pandemic already has them as underlying sentiments. Nevertheless, through the game design, multiple features were designed to deliver a better experience to children. Thus, the result was the addition of protective frames that were not directly related to the "Challenging" rich experience but a sense of danger.

6.4 Guidelines

Throughout the project, the team has noted the design approaches and techniques attempted to show what has been beneficial or did not work. This section aims to pass on learnings to the reader by listing guidelines that the team developed working on this project. These guidelines will be explained in relation to the results, methodology, theory and background of the project.

6.4.1 Engaging Learning Experiences

This category of guidelines shows what approaches have worked to create an engaging learning experience. These guidelines include how to approach the design process to involve a learning experience from a UX perspective, the specific guidelines about the length of the experience, and how to approach the a learning topic.

- **Incorporate backward design into a design process**

  Assuring that the solution adequately introduces the desired learning goals and that the experience nudges the user into understanding them is always a challenging task. In that sense, the backward design turned out to be a valuable and insightful model to include in the design process of a solution. Because of its three stages, the backward design brings to the table a different approach to keep track and deliver the learning goals.

  The first stage, *desired results* [30], can help the designers set a clear and achievable learning goal. For this project, the learning goals were determined in Chapter 5.4.1.4 (Figure 5.10) during the exploration of the solution space [16], and in the define phase of the *design sprint* [4]. Likewise, these learning goals set expectations to what would the learners be able to do thanks to the new learnings. This process, by itself, puts constraints (a common property of the *define* phase due to its convergent nature [16] [4]) and sets reasonable expectations for the future learning activities in *stage 3* of the backward design [30].

  The second stage, *evaluation assessment*, assists the designers to conceive how they could assess the learnings throughout the experience. Within the project, the assessments were specified during the *decide* phase in the Figure 5.14, they were displayed in contrast to the *learning goals Stage 1 - Desired Results* of the *backward design* [30].
  This process isn't as straightforward or intuitive, since it requires considering valid ways to assess understanding like self-reflections [30]. Although it sets a good precedent for a solution's evaluation process and can go hand-by-hand with it in the form of e.g. interviews [34]. Nonetheless, a clear distinction has to be made between which evaluations (or parts of them) assess the learning goals and which ones evaluate the artefact's features. This can be seen in the Chapter 6.2.0.2 following results of the *backward design* - stage 2.

  Lastly, the third stage, *learning activities*, represents all the activities that will ensure the delivery of the learning goals [30]. For this project, this can be seen in the *Chapter 5.4.3.2*, Figure 5.15. Thus, after listing all the activities and how they would be assessed within the second stage, laying them out with the help of storyboards resulted in a smooth and entertaining creative process. An example is displayed in the resulting storyboard in Chapter 5.4.4.1, Figures 5.18 and 5.19.

- **Make the experience short and sweet**

  The experience needs to be short enough to keep the children's attention, particularly if the child in question participates at a guardian's or teacher's request. The results of the evaluation sessions (Chapter 6.4.3 - Remote Moder-

ated Research), the team found that the participants were satisfied with what they've seen after two to three playthroughs of Pawdemic (four attempts as a maximum). Each attempt was, on average, 1.5 minutes long (Table 5.4). For instance, in this particular project, the sweet spot for the length of interaction might be around five minutes of playtime.

The discovery set a potential constraint where, if an experience takes longer because of more content or replayability, it is crucial to arrive at the learning goals (Figure 5.10) within five minutes. To some degree, this could prevent losing the players' attention before they have a chance to learn.

- **Make learning experience stimulating through a challenge**

  Thanks to the results of the evaluations with the Smileyometer in Chapter 5.4.6.1, the team found that giving children obstacle to overcome worked well and that they found that the challenge was gratifying - even when losing. The *rich experience* framework represents events like these as part a of *the challenging* rich emotion, commonly used in puzzles [24]. Thus, making a player face something that makes them curious and challenges their skills can evoke an intrinsic motivation that makes them *want* to solve it. That motivation could be harvest with the purpose of teaching them something valuable, if there's a clear learning plan behind it, such as the backward design stages [30].

- **Select concise and applicable topics**

  The general definition of "social distancing" as a learning goal took place within the exploration of the problems space in Chapter 5.3.2.3 thanks to the workshop's insights 5.3.2.2. Nevertheless, specifying and selecting how to concretely achieve that learning arrived within the exploration of the solution space [16]. More specifically, while defining [4] the first stage of the backward design [30] in Figure 5.10. The specific goal was to learn about the "Three Cs" of social distancing: avoiding close contact, crowded places and closed spaces [61]. Such a clear and simple definition of the learning goal turned out to be successful once the team compiled and verified the learning evidence (Chapter 6.2.0.2). Children reflected about their experience stating the need to avoid others when they are *"[...] too closed or [it's] too crowded"* and that *"[...]it's important to keep distance"*. Furthermore, children responded positively to learning about things that they can apply in their everyday life such as social distancing "when going in the mall" (Chapter 6.2.0.2).

  In this project, the team narrowed down the wicked problem of tackling a frightening topic (COVID-19) to social distancing, and further down to the three C's. For instance, in light of the positive results displayed by the evidence, the team considers that it is best to set the learning goal as practical,

useful, and concise, as possible to have a better chance to deliver the understanding.

6.4.2 Emotional Considerations

The guidelines in this category are very focused on answering the emotional aspects of the first research question. The use of the *rich experiences* framework was supposed to complement the learning experience by explicitly considering what emotions users could feel while learning. The goal of that approach was to be mindful of possible negative emotions relating to the topic, but as the team tested the combination of methods and developed it further, the team realized that it made perfect sense to utilize the *rich experiences* framework to enhance retainment of information as well.

- **Make learning experiences impactful using Rich Experiences**

  The rich emotions framework exists to make experiences that are enjoyable, memorable, and have a more profound effect on the user. These traits are usually also what denotes a powerful learning experience. The team found that combining the rich emotions framework with backward design to create learning experiences helped create more impactful interactions that were more likely to leave a lasting mark on the user, helping retain knowledge.

  Taking into account the terms *learning experience* [5] and *rich experiences* [24], related to this study, the team considered the idea of a *Rich Learning Experiences* framework, where regular learning experiences would include the use of rich emotions to leave a significant impact on the learner. Rich experiences are described as notable and memorable by nature when implemented correctly. [24] Cavanagh S. R. says that *"Emotions can harness attention, maximize working memory potential, enhance memory consolidation, and motivate learners"* [63], therefore, the team believes that the usage of rich emotions is a good solution to designing a truly memorable learning experience.

- **Use another Rich Experience Framework to Subvert the Original Negative Emotion**

  When used correctly, the rich emotions framework can help guide a user's emotions according to the designer's intentions. In this sense, a designer can also divert the user from their initial emotional state caused by the perception of a frightening topic into one that allows for more enjoyable and emotionally considerate learning. For example, by designing for a challenging experience such as *Pawdemic*, the designer can guide the user into frustration and then into satisfaction, moving them away from their initial feelings of fright. An approach like this is beneficial if the designer doesn't want the user to feel

frightened as part of the experience.

- **Avoid unnecessary details of a sensitive topic**

  Following the guidelines of backward design, the team defined a concrete learning goal and then decided to exclude any details that do not relate to the chosen learning goal [30]. While the exclusion intended to make the learning topic clearer, it had the added effect of reducing the presence of the sensitive topic as advised by the NYU guidelines for communicating with children [33]. The lack of references to symptoms or sickness creates fewer reminders of something potentially distressing for the user, helping the experience avoid eliciting unwanted negative emotions. Figure 6.4 shows an instance of this approach being used in *Pawdemic*. The game informs the user of danger and that they're doing something wrong by colliding with other people through abstract imagery that doesn't reinforce the fear of coughing, sneezing, or viruses. The final version of the game in the project has no references to sickness, symptoms, death, or hospitals beyond mentioning a pandemic in the title.

- **Include Protective Frames for underlaying emotions**

  The use of rich emotions requires appropriate protective frames to make the experience safe and enjoyable. When working with sensitive topics, a user might feel negative emotions due to the subject rather than a designer's conscious decision, which might require additional protective frames.

  The team recognized that exclusion of some potentially frightening details helped adjust the tone, but a frightening topic can still permeate the user's mind simply due to the context of the game they're playing within the worldwide situation. As an added precaution, the team again consulted the *rich experiences* framework and added additional protective frames. While the game is designed around the challenging emotion and makes use of the control frame to regulate the expression of frustration, the game also includes the detachment frame by presenting anything negative to be happening only to the game character (Fig. 6.7). The detachment frame alleviates feelings of fright or anxiety that the user might subconsciously carry into the experience. The main takeaway is presented as a guideline to include additional protective frames for possible underlying emotions as an added emotional precaution.

- **Turn small interactions into rich experiences**

  Pawdemic has an overarching rich experience that the team wanted to player to feel, which was the "Challenging" emotion [24]. Besides the main emotion, the team also looked at smaller interactions and how those could feel mean-

ingful. One of these is the process of moving in and out of the danger zones (Fig. 6.4), where the user will feel fright because of the danger and joy from escaping successfully. These are the components of the "Thrilling" emotion, and the process of navigating the danger zones can be seen as a separate rich experience that is part of the larger experience.

This led the team to believe that you should allow the use of rich experiences to permeate the design process. Do not limit the use of the framework to the big picture of the design. Consider how even trivial interactions can become rich experiences of their own by considering the emotions involved.

6.4.3 Participatory Design with Children Online

The guidelines presented in this section aim to help designers organize and conduct studies remotely. The team has created many of these guidelines based on the difficulties experienced with remote participation or distributed participatory design [9] and believes they can help others avoid making the same mistakes.

- **Globalize user participation when appropriate**

  The team's initial difficulty of finding participants for the study helped highlight one of the strengths of involving users remotely: the selection of users can go beyond the researcher's location [18]. Moreover, the global effects of the COVID-19 pandemic allowed the team to explore outside of the physical location and not be limited only by a local target group.

  Although English is a widely spoken language around the world, when it comes to involving children, in most cases, they might not be proficient in it as a second language by the age of 9-12. In consideration of this, the team prepared the workshops in three languages: English, Spanish and Swedish (Chapter 5.3.2.2). Furthermore, in *Pawdemic*, the first thing the player sees is a language selection (Figure 6.9). As the results show in Chapter 5.4.5.2, the evaluations of the artefact were also carried out in three different languages.

  For instance, provided the research topic allows it, designers could look for users outside of the initial local scope. Although the language skills of the members of the team also represent a challenge to consider.

  Nevertheless, a caveat to the globalization approach is that the team must account for cultural differences and how a translation can carry a different nuance from the original message. In the project, one unexpected result (Chapter) was that Peruvian participants couldn't relate the Spanish flag with the Spanish language, as they might associate the Spanish language choice with the Mexican flag as a symbol. Another outcome was that a Swedish translation of the word "crowded" to "trångt" caused Swedish participants to perform worse

on the quizzes since the word has a secondary meaning that causes ambiguity in the answers. If the design relies on users having a specific cultural background, or previous experiences, the globalization approach might not work.

- **Be aware of the user's computer literacy**

  Another aspect of remote participation that became apparent was how much the team needed to work around technological solutions. The team used a digital canvas tool called Miro [1] to create a tool for the *kidReporter from Earth* workshop. While Miro is a tool for expert users working in design, the team thought that Miro could work for the workshop with enough preparation, challenging previous studies that suggested a flawed performance [18].

  Specifically, the canvas made for the workshop included a large white box and a palette of emojis that the children could drag and drop to create an image as part of a workshop task and didn't require any other input (Fig 5.5). While it seemed fine during testing with expert users, children struggled to interact with the canvas, as their inexperience with using computers created issues that the team had not foreseen. One participant clicked and held the mouse button whenever they wanted to select something, which Miro interpreted as trying to choose something behind an object. Another participant had trouble clicking and dragging objects because they attempted pressing left-click once before trying to move elements which instead caused them to select it and brought up a menu of options in Miro.

  Thus, these issues made the team take a step back and realize how much of an issue computer illiteracy could be in remote studies. Future work must account for this by offering simple-to-use interfaces or relying on verbal and visual communication over a conference call. Likewise, it's better to avoid expecting children to switch between programs or windows, use keyboard shortcuts or other complex mouse commands. Other accessibility and redundancy aspects will be presented further upfront.

- **Work around latency issues with local solutions**

  Latency issues in online communication are common. It might sometimes be hard to see what is happening on camera feeds or streams, and remote-control solutions can feel very clunky. Through the evaluation with experts (Chapter 5.4.5.1), the team found that anything involving animations or videos are not suitable for streaming in an online call, and presentations with still images work better. When possible, allow users to open tools, videos, and other material locally on their devices. A solution could be sharing files or links to websites with the relevant resources rather than asking them to interact through screen-sharing or remote control of a researcher's computer to avoid

input delay. If screen-sharing or a camera feed is required, make sure that the connection is stable enough that it will not affect the study negatively.

- **Design short participatory workshops**

  In consideration of the length of the different activities carried out with children, the *Mission from Mars* workshop (Chapter 5.3.2.2) was the one to take longer: around forty minutes. Although the results were very positive, the workshop length was problematic when organizing the workshops with an institution, such as a school. Thus, researchers must be mindful of the possible disruption that their research might cause in a school's schedule remain flexible.

  In contrast, the evaluations sessions with children (Chapter 5.4.5.2) took between fifteen to twenty minutes. These evaluations delivered a much better experience, not only for the participants but for the team, allowing them to execute multiple evaluations one after the other. Lastly, although children's attention span is relevant to consider, the positive results (Chapter 5.4.6.1) suggest that the different workshops and evaluations managed to keep their interest and motivation.

- **Request help from other institutions**

  As pointed out by one of the interviewed experts when studying the problems space (Chapter 5.3.1.2), a school or similar organization can usually help forming groups of children where they are friends and comfortable enough to discuss and work together. This also allows them to participate from one physical location and eliminate communication barriers that might be present if they are communicating over an online call.

  In the teams' experience, reaching to institutions, clubs, and schools for help reduces the number of people that the team must contact individually and organize. Moreover, guardians are more likely to let their children participate in studies through an organization they already know.

  Lastly, to increase the odds of receiving help from an organization, designers must be mindful of the organization's time and not disrupt their schedule more than necessary. The team noticed a better response when presenting a short study (fifteen minutes). Accommodate one large study in multiple smaller sessions could also be beneficial.

6.4.4 Improving the Flow of the Digital Learning Experience

The guidelines relating to the flow of the digital learning experience aim to improve accessibility for the target audience when interacting with digital artefacts. They come from improvements of the team's design after identifying what aspects children commonly struggled to use or understand. The presented advice aims to reduce potential technical hiccups and usability issues. The main finding was that a digital artefact should include redundancy in both input and output. The redundancy increases accessibility for users with disabilities or other issues, which in design usually results in improved usability for all users [64] making the experience easier to understand for everyone.

- **Redundancy in presenting information**

  There are multiple instances of redundancy in *Pawdemic*, such as the images and the text in the tutorial (Fig. 6.3), the sounds accompanying the damage indicators (Fig. 6.4) or the images next to the choices in the quiz (Fig. 6.6). The target audience of 9-12-year-olds is generally able to read, but children vary in their reading proficiency. Based on that, keep the text short and simple, and consider providing alternate forms of communicating information, such as images and audio. Children should optimally fully enjoy an experience without understanding one of the modes of communication to accommodate children that cannot read, are deaf, or have visual impairments.

- **Provide redundancy of inputs**

  In *Pawdemic* the team initially designed the game to be playable with just the keyboard, believing that having just one form of interaction would make it easier to understand. During testing, players surprisingly often reached for the mouse to interact with certain parts of the game. After witnessing this, mouse support was added to the game while still allowing just using a keyboard. Users could now choose how to approach it based on their preferences. By offering numerous approaches to interaction, the game is more likely to accommodate input that feels natural. Figure 6.6 shows the quiz interface, which shows the user that they can use the arrow keys to navigate while offering the same functionality using the mouse. Similar interaction prompts appear throughout the game and, all work with both the mouse and keyboard.

  Since children showed issues with computer literacy, it is wise to lower the entry barrier for partaking in an experience by allowing users to dictate how they want to interact with the design. After designing how a user should interact with an artefact, the designers should evaluate how children approach using it and if they might attempt other modes of input than what the designers imagined. The best solution is to allow for flexibility in usage, where

the user can choose between tools like a keyboard or mouse to pick whatever they feel is most comfortable.

7
Discussion

This chapter discusses the design process and the results of this thesis in terms of the research questions. It contains learnings from the project and motivations for the generated guidelines by discussing what has worked and how previous literature supports the conclusions.

7.1 Results

This section discusses the main results presented in the previous chapter. The discussion includes whether they have met the team's expectations, motivations for the design choices, and what insights the team could draw from them.

7.1.1 Pawdemic

The main criteria for the success of Pawdemic, the digital artefact, were whether or not it delivered the intended learning experience and whether it did so in an emotionally considerate way. If the artefact successfully fulfilled those criteria using the design process guidelines created by the team, it could also serve to validate them.
Stage 2 of backward design, evidence of understanding, tackles the validation of the learning experience. The previous chapter contains the list of criteria for the validation and the corresponding results. Based on those results, which included observations from the team and the children's self-assessment, the learning experience delivered the intended knowledge to players.
Furthermore, the evaluations involved assessing the player's perception of the game, including measuring how much they enjoyed various parts of the game through the smileyometer and interview questions asking players to express how they would describe the game. In the descriptions, most children mention that the game feels positive thanks to the utilization of vibrant colors and a cute aesthetic. None of the children thought that the game was scary or otherwise gave off a negative feeling. The children rated that the game made them feel "good" and even expressed that the experience of losing was positive, which the team thought could be the most likely catalyst for negative feelings.
Since the game appears to fulfill its purpose, and children find it both educational and fun enough to replay, the team believes that the developed guidelines succeed in creating an emotionally considerate learning experience with a remote participatory approach.

7.1.2 Backward Design

This discussion will contrast the "desired results" determined in the *Stage 1* (Figure 7.1) and the results gathered in the *Stage 2 - Assessment Evidence* as part of the summative evaluations with children to assess the learning goals of the digital artefact.

Figure 7.1: Desired Results from Backward Design - Stage 1

- **D. What Key Knowledge and Skill will Players Acquire as Result**

  The team validated that children could recognize risky situations and unsafe places when playing the game by solving most quizzes without any issues. Moreover, the team validated that children understood the risk of the scenarios by noticing that spending too much time close to other characters could make them lose the game.
  Children were aware of the preventive measures they could take, like cleaning their hands in the tutorial level and alter, avoiding other characters as much as possible. Likewise, children communicated effectively about social distancing and the consequences of not being careful in risky situations. Some children pointed out that they have not learned anything particularly new. Nevertheless, when self-assessed, they reflected effectively upon the potentially dangerous scenarios. Some pointed out that *"if you are too closed or [it's] too crowded, [the] virus might spread"*, and others highlighted the need to *"clean their hands"* and *"respect the social distancing"*.

- **C. What Understandings are Desired**

  Based on the previous evidence, it is safe to say that children understood how social distancing acts as a preventive measure to avoid getting infected

with COVID-19. Children did not only inferred the disease the game was addressing but provided reflections like *"[you] need to keep the distance from people so you won't get sick"*, and *"Keep the distance to stay safe"* reinforce this statement. Children also successfully distinguished between the scenarios in the quizzes that represented risky situations with close contact, closed spaces, and crowded places.

Thus, by addressing all the items related to the specific learning goal and it's implications, phrased as *"Players will use an understanding of the 'Three Cs' of social distancing: Close contact, Crowded places, and Closed spaces"*; te team can assert to have delivered the learning goal *"Players will understand essential concepts about social distancing and the spread and prevention of COVID-19"* through the digital artefact.

7.1.3 Rich Experiences

It was a team design decision to focus on the creation of a "Challenging" rich experience, commonly perceived in puzzles, or cognitive stimulant activities obstacles are overcame [24].

Figure 7.2: Underlaying Emotions within the Digital Artefact

Nevertheless, after analysing the results of the rich experiences, it became evident that the additional protective frames were directly related to a sense of danger (Figure 7.2). Thus, the team noticed and understood that it represented the implicit involvement of another rich emotion: "the thrilling". This experience leverages "fright" and uses protective frames (safety-zone or detachment frame) to elicit a sense of joy [24].

Thus, as it turned out, the sense of fright, implicit in the topic, could not be easily avoided. Moreover, it was also built-in in the solution regardless of the attempts to avoid being explicit about the subject.

Nonetheless, this led to the understanding that borrowing protective frames from the rich experience that involves "fright" could help avoid its negative effects and, in consequence, alleviate the sense of danger. The team believes these actions cleared up and secured the path for the initially planned "Challenging" rich emotion to be successfully delivered.

7.2 Research Approach

The flexibility of the exploratory research approach allowed the use of frameworks from other fields like the *backward design* from instructional design and the involvement of emotional considerations by the use of the *rich experiences* framework. The team believes that the impact of these theories was invaluable to the success of the project. Thus, the results of this research approach have left insightful guidelines and information to designers interested in learning experiences and the application of rich experiences into learning activities. Moreover, helpful guidelines for cases in which both could collaborate to strengthen learning experiences.

Also, while working on this project, the team gained a good understanding of the target audience, children between 9-12 years old. Learning about their perception and understandings of the COVID-19 pandemic contributed to a better conception of the *research through design approach*. This, in turn, led to creating a suitable digital solution that was meaningful to the target audience and addressed the project's research questions. Moreover, the artefact served as a vehicle to formulate and validate guidelines that provide new insights and findings of designing learning experiences, the backward design, and the rich experiences framework.

7.3 Design Process

This section presents a discussion of the different methodologies and frameworks involved throughout the design process.

7.3.1 Design Sprint

The first iteration of the project followed all of the Google design sprint's phases [4], and the team found the structure to be the remarkably adequate. The subsequent iterations revolved around validating and updating the prototype. Thus, because of the scope of the digital artefact, the team was not able to do a complete re-run of the design phases within the given timeframe. Moreover, there was only one ideation sketching phase, since the rest were only feature-related sketches, and no other major changes were taken into consideration.

Due to the team only consisting of two members, the deciding phase was mostly common agreement. During the first iteration, an outside expert joined to aid in deciding, but since the two team members communicated throughout the project, any formal decision-making process seemed unnecessary, especially when no democratic consensus was possible and decisions could be simply agreed upon.

The need to develop the game, besides just designing, made it more difficult to do multiple complete iterations of the Google design sprint. The game development took large amounts of time and had to take place in parallel with the design process. Decisions often became final since the team would need to re-code and re-validate any significant changes. Once certain features became finished, it wasn't viable to completely pivot away from them within the timeframe with a single developer.

7.3.2 Learning Experience Design

The process of creating meaningful learning experiences follows in great depth the ground knowledge of instructional design and user experience design processes [32]. Thus, the team was aware of the existence of many learning experience design processes and frameworks to follow. Nonetheless, while diving into the instructional design theories, the backward design [30] presented itself as an interesting, simple, and very hands-on design approach that could very well fit the purposes of a *research through design* approach.

In hindsight, the backward design turned out to be an ideal framework to blend in the design process that helped the team hold onto the learning goals and the activities that would deliver the learning experience. Thus, the design process of this Master's thesis project resulted in a new and unique approach to design learning experiences. A process that could also set precedents for new *Learning Experience Design* frameworks that don't only tackle learning experiences through interactive digital artefacts as in this particular case.

On the opposite side, it is relevant to note that because of the nature of the backward design (considering the desired results first), it is effective to set a clear direction for a project in terms of learning activities. Thus, the learning goals did not mutate during the design iterations. They remained unchanged and indifferent to the medium, shape, or form that the learning activities and evidence assessment could take. For instance, the team noticed a clear contrast when running an iterative

design process. Where, in this particular case, the learning goals remained constant after the first iteration.
Lastly, presenting the learning activities is a task that could be easily, and very successfully, replaced within the learning experience design process. The results of this project suggest that other design methods can represent the learning activities in a much more efficient way, like with a thorough low fidelity prototype, or a storyboard.

7.3.3 Remote Participatory Design

Due to the worldwide situation caused by the COVID-19 pandemic, the team knew from the beginning that this project would have to be remote. Rather than seeing it as a hindrance to the project, the team figured that it would make more sense to make the most of the circumstances and establish guidelines for the remote participatory research part of the thesis.

Previous experience with remote learning meant that the team already had a good grasp of available online tools. The worldwide situation also contributed to an increased understanding and acceptance of online tools in our user group and their guardians.

In practice, most of the online correspondence happened through Zoom, save for when there was a personal preference or requirement for another video conferencing tool among users and experts. The choice of Zoom as the preferred videoconferencing tool came from familiarity with the software within the team and users due to its prevalence in remote learning during the pandemic and the various tools it includes for screen sharing and remote control.

The team learned a lot from doing most of the design process online and codified the most valuable learnings in the guidelines. In general, the team believes that a remote approach is laborious to do correctly due to the lack of physical presence and reduced interpersonal connection. Thus, pre-runs and validation sessions with experts are recommended. Remote participatory design is best suited to designing things that the user can fully experience from their computer or other device, such as software, video, imagery or even written stories. Testing design artefacts that include physical components creates additional issues in the delivery of components and setting it up somewhere the user can access it. These problems are not impossible to overcome, but the team would advise against testing tangible designs remotely.

7.3.4 Evaluation Process

The design process has followed the planned structure for the most part, except for the user research. Almost all deviations from the plan originate due to delays in finding users and organizing the workshops. To keep the project on track and avoid a chain of delays caused by the research, the team resorted to other means of collecting feedback and data in the meantime.

A notable change was the unforeseen amount of reliance on expert feedback to complement the user research. When the team could not find users and organize evaluations by the time other design methods required results, the team brought in experts for online interviews, usability testing, and heuristic analyses. The feedback from the experts was not a replacement for the user feedback but helped the team by pointing out things like usability issues and allowed the team to continue the development of the game.

In the end, the team realized that the addition of expert feedback was valuable not only to be able to continue with the project but to find issues that children couldn't express their opinions on sufficiently. Experts were able to point out specific details that need change and could motivate their feedback with theory and experience, while the user feedback was often subjective or unclear since the users themselves weren't sure why something wasn't right.

Towards the end of the project, the team finally managed to get in touch with an organization working with homework assistance for young children. This organization aided in organizing multiple rounds of evaluations and helped the team get in touch with a school with which the team could conduct further research. Although majority of the participants were females (8 out of 10), this help meant that the project ended with a satisfactory amount of user research to validate the guidelines, while the expert feedback helped the team finalize the design that users evaluated with the team.

7.4 Ethical Considerations

It's crucial to consider the potential effects of leveraging negative emotions to obtain positive experiences in children. It is difficult to get good data about something that is naturally frightening or incites other negative emotions in users without accidentally subjecting users to those emotions. Having an open discussion about COVID-19 and viral infections with children during the current circumstances is a challenge that will require many safety procedures regarding parental consent and careful consideration of their mental health. The team understands that scientific findings cannot be an excuse to cause distress or discomfort to participants. The team has held that the study participants' wellbeing is more important than any possible scientific findings and will continue to prioritize accordingly. The studies provided reminders for participants that they are in control of their participation and are allowed to pause or leave the study at any time.

Some of the emotional precautions that the team set up involved the language used when communicating with users, both during workshops and in the game itself. There is no mention of topics like death and hospitalization due to the team's belief that merely making children think about these things could cause feelings of fear, anxiety, and worry. In the end, the team went as far as avoiding mention of any symptoms, focusing instead only on the concept of social distancing. While some

users mentioned these topics during interviews, the team never prompted them to do so and tried to move away from the subject in a considerate manner to avoid focusing too much on the negatives. The game does not show anyone being sick; there is no imagery of viruses, coughing, sneezing, or mention of illness in the task descriptions or goal of the game.

Many of the ethical considerations follow the guidelines outlined by *New York University Child Study Center* [33]. Besides helping the team communicate the subject matter to children, the guidelines also helped to make the team aware of how they treat the participants. When discussing difficult subjects with children, it's important to not minimize their fears and to treat them with respect and understanding. Children are the experts of their own experience and it is up to the design team to treat them like any other experts and listen.

Any new insights on how to tackle sensitive topics can positively impact the current understanding of children's learning experiences. The team hopes that a considerate approach to studies like this can benefit the field and how children learn about tough topics.

Besides the purely emotional considerations the team also took pre-emptive measures regarding data collection by opting not to record any video, audio or take any photos of the participants.

7.5 Future Work

There are aspects of the research that require further investigation, but the work in this thesis has been limited by the time and resources of the team. Future work could include repeating the research presented on a larger scale or using the guidelines for a different topic than the COVID-19 pandemic.

Since one of the main hurdles that the team experienced was the difficulty of finding users, a potential future continuation of the research could include repeating user studies on larger scale for greater statistical significance.

7.5.1 Further development of digital artefact

The game is missing a real sense of replayability in its current state. The team wanted to rectify this by including reasons to revisit the levels. Some of the ideas that that team wanted to implement but did not have the time for included:

- **Character abilities**
  To make the character choice more meaningful, the team wanted to include more characters for further customization, and provide all characters with a unique ability. This ability would be a single powerup or advantage that only that character had, such as increasing the time allowed to stay within a danger zone for a character with a mask or clues as to which answer was correct in a

quiz.

- **Randomized tasks**
  If the player wasn't met with the same tasks every time they player the game, the player would not feel that there is nothing new to see after a single playthrough. This could be achieved by having a larger pool of photos to collect and only assigning some of them at random per playthrough.

There are also some small bugs and features like mobile support that the team would like to develop further.

8

Conclusion

The thesis started with a broad topic with many unknowns. Throughout the project, the team found valuable insights regarding remote participatory design of educational experiences with children and design around potentially frightening subjects for children. The team used the findings to create a digital artefact to test, analyze and validate answers to the two main research questions of this thesis:

- **How suitable is the Rich Experiences framework to leverage negative emotions when introducing potentially frightening topics to young children?**
  The rich experiences framework gave an appropriate approach to designing an emotionally considerate game. The team learned that using protective frames for underlying negative emotions when handling sensitive topics could minimize their effect on the user, allowing designers greater control over the user's emotional state. These findings are found in the *Emotional Considerations* category in the results chapter. The team also considered enhancing learning experiences using the *rich experiences* framework to create what was called *rich learning experiences*, as detailed in the guidelines for *Engaging Learning Experiences*.

- **What are some possible considerations when creating an engaging learning experience through an interactive digital artefact for children?**
  Incorporating backward design into the UX design process helped the team to keep track of the learning goals, and in turn, create the categories of guidelines regarding *Engaging Learning Experiences* and *Improving the Flow of the Digital Learning Experience*. The successful combination of backward design with the principles of user experience design points to the strengths of the combined field of learning experience design. The approach has proved to be good at creating experiences that are both enjoyable and educational.

The methods and approaches presented in this thesis define and tackle a wicked problem, eventually whittling it down to an approachable solution. The decision to answer these research questions and the broader wicked problem of teaching children about sensitive topics online has also resulted in additional guidelines regarding *Participatory Design with Children Online*. The team hopes that this research can inspire future work in further developing rich learning experiences, the handling of sensitive topics and remote participatory design.

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