Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

Long Thanh Thai

How to create intuitive game mechanics

Master's thesis in TDT4900 - Computer Science
Supervisor: Alf Inge Wang
Co-supervisor: Rabail Tahir
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TDT4900 - Computer Science, Master's Thesis

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June, 2022

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1 Introduction

There has been a growing study of intuitive interaction with user interfaces that offers more insight into what insight is, what it means to measure different aspects of intuitive interaction and guidelines for designers to design interfaces that are intuitive. Research in intuitive design has mostly focused on interfaces with a utilitarian purpose, but very little research has been performed on the field of video games. Usability is a very important aspect of video games which could benefit from more research in intuitive interaction.

This paper is written in collaboration with Umble, a ux- and desig studio based in Trondheim, where I work as a developer and I am also in charge of play testing. In Umble we are working on game on behalf of the Sami parliament. Umble has previously not had any experiences in creating video games, but has a lot of experience with consultant work like branding and website creation. Working with this design team on the game has proven to be a very interesting experience because the design team has a lot of knowledge of intuitive interface design. The design team has incorporated a lot of interface design principles like Don Normans' in the design phase of the game interactions, which is a topic that has not been explored previously in research papers. This paper will explore if interface design principles can be used as general guidelines to help create intuitive game mechanics, using the Sami game as the test subject.

Nowadays, the general public has little knowledge about how it is to be a Sami person in modern society. People generally only know Sami people as northern tribe people that herd reindeer and ride around in snow scooters, but the truth is that there are many Sami who live among the general public as normal citizens. The goal of this game is to immerse the players in a story about a modern Sami to both educate people and make people interested in the modern Sami culture.

The game is an interactive drama for the mobile phone that is about the challenges of growing up and finding their identity. Noa spends his childhood summers with his cousin Inga and their Sami family located in northern Norway. As Noa grows older he grows steadily further and further away from his family. Not before meeting Inga again in the future does he understand what his family and heritage means to him.

2 Related Work

This section contains the background work that has been done for this paper. This involves getting inspiration and information from playing games with similar concepts to the game developed in this paper, reviewing other literature about intuitive interactions in video games or similar domains, and reviewing literature about research methodologies and guidelines developed to test intuitive interaction.

The games that were explored in this section has been the inspiration for the Sami game since the beginning. These games were found through friend recommendations, from video game awards and from past experiences. The literature review was done by reviewing research papers based on keywords "intuitive", "game design", "mobile game" and "interactive design". Three games were selected and played through and discussed by everyone in the game developer team. For this related work section a total of five research papers were selected and studied to inspire the research methodology that is used in this paper.

2.1 Game mechanic inspirations

The game mechanics are inspired by a large number of good games, but three are particularly noteworthy.*Florence*(Mountains 2018), *Consume Me*(Hsia and Thomson 2019) and *Night in the Woods*(Secret Lab 2017) are three games that has succeeded in incorporating mini game mechanics to seamlessly fit into the story.

2.1.1 Florence

Florence is an interactive drama that explores the different sides of being in a relationship. We have especially taken inspiration from the games use of simple touch interactions that makes the players sympathize with the characters. Florence lets the players perform "boring" actions, like for example brushing their teeth, as shown in Figure 1. This creates a connection between what we are doing (routine and boredom) and how Florence (the main character) feels.

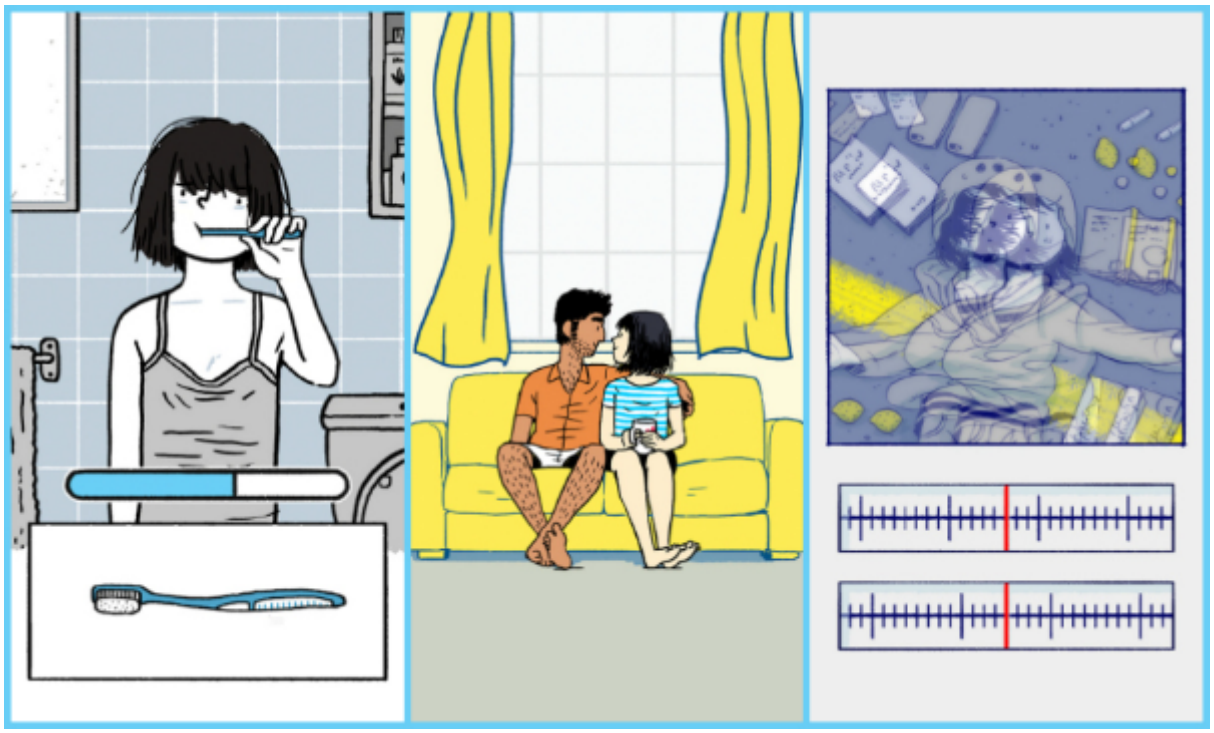

Figure 1: Screenshot from Florence(Mountains 2018) showing the simple mechanics of the game

2.1.2 Consume Me

Consume Me is a story about the characters' relationship with food and has a dark and humoristic twist. The project started as a collection of prototypes inspired by the creators past experiences with diet and unhealthy eating habits. Like Florence, Consume Me uses simple interactions to give life to the characters in the game. The game constantly surprises the user with new types of interactions. This makes it so the user is always excited for the next interaction. Figure 2 shows how the mechanics coupled with the weird art gives the user a feeling of intrigue.

Figure 2: Screenshot from Consume Me(Hsia and Thomson 2019)

2.1.3 Night in the Woods

Night in the Woods is an adventure game based on exploring the story and the character. It has a plethora of exciting characters and a lot of exciting things to explore in a lively universe. The most interesting aspect of the game is how the game combines the dialogue boxes and the gameplay, which is shown in Figure 3. Dialogues are often short, but with a lot of personality. This will work particularly well for mobile games.

Figure 3: Screenshot from Night in the Woods(Secret Lab 2017)

2.2 Intuitive Game Design Research

This section explores the research articles that have tried to implement intuitive design and theories into a product. The two relevant papers that have implement intuitive design and theories into products are *The Invoker: Intuitive Gesture Mechanics for Motion-based Shooter RPG*(Quek and See 2015) and *Natural mapping and intuitive interaction in videogames*(McEwan et al. 2014).

2.2.1 The Invoker: Intuitive Gesture Mechanics for Motion-based Shooter RPG

Albert Quek and John See published in 2015 a paper about their game *The Invoker*, which is a Shooter Role Playing Game(SRPG) that uses the Microsoft Kinect that allows the players to use gestures to control their character in the game. The game takes place in a fantasy world where the player plays an apprentice wizard that has to overcome a set of level puzzles, challenges and boss battles to become a master wizard. The game relies heavily on hand and body movements to perform various actions. Spell casting, dodging, shielding and healing all have specific geometric shapes associated to them and the player draws the shapes using their body to perform these actions, which is shown in Figure 4.

To test the intuitiveness of the game, Quek and See tested the game on a target audience that had an interest in fantasy role-playing games. They had 13 participants ranging from 18 to 20 years old and the users were given 15 minutes to play. Then, Quek and See ran qualitative survey and interviews. The results showed that 70% of the participants enjoyed the gesture mechanics and the users were able to complete the game with minimal or no assistance, which is what Quek and See has defined as intuitive gesture game mechanics.

Figure 4: Screenshots from The Invoker(Quek and See 2015)
showing some of the gestures.

2.2.2 Natural mapping and intuitive interaction in videogames

This papers' goal is to research the claim that newer control devices for videogames are intuitive. The paper seeks to verify the claims by applying and adapting existing intuitive interaction theory and tools to evaluate naturally mapped control interfaces(NMCIs) for videogames. The control devices that were tested are shown in Figure 5. NMCIs are supposed to allow the player to achieve much more freedom in how they execute control actions, with a potentially finer degree of control than traditional controllers. The example shown by McEwan et al. was that it is more intuitive and satisfying to swing a sword in the video game using a wand controller (like the Playstation Move) over a traditional controller.

The paper also explores two groups of researchers, Blackler et al. and Hurtienne et al., that has used decades of research and theory in cognitive science to tie intuition to previous experiences. They discovered that intuition is the end result of a cognitive process that matches current stimuli

with a store of amalgamated experiential knowledge, built up through time in similar situations. Through this research they determined that intuitive interactions should be the correct action in the context of use, which can be much faster due to the increased speed of subconscious rather than analytical processing. This also means that response time and accuracy are common measures for intuitive interactions.

They explain how a product can have a high potential for intuitive use if it is designed to take advantage of experiential knowledge that is broadly possessed by its target audience. To find out how this can be done, McEwan conducted a user study where the participants played a racing game three times using three different controllers. Additionally, an interview and multiple surveys were conducted. They ran an initial survey called the game technology familiarity questionnaire to determine the participants familiarity for each NMCIs. After the participants had completed the game with one controller the researchers had them answer another questionnaire. Next, the participants were interviewed regarding their experience using the controller to capture qualitative data about the participants likes and dislikes of using the device.

McEwan and his group of researchers used two measures to objectively assess the intuitiveness of each control interface. The first measure was titled Progress, which was the percentage of the race that was completed after four minutes had passed. The second measure counted the significant errors committed by the participants to assess the intuitive interaction during play. Other common measures for intuitive interaction are time to complete set task, codified intuitive uses and accuracy, which were mentioned in the paper, but not used during testing.

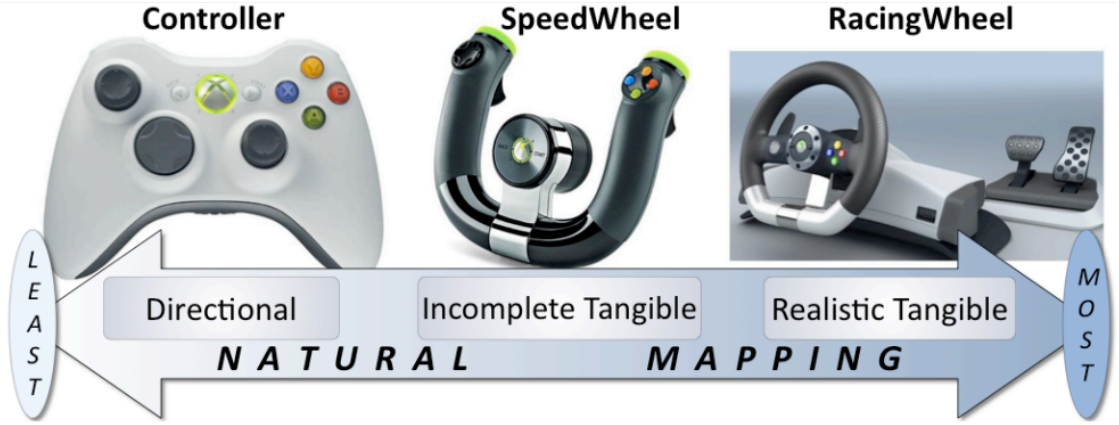

Figure 5: Naturally mapped controllers that were tested

2.3 Evaluation Frameworks

This section explores the papers *Usability Metric for Mobile Application: A Goal Question Metric (GQM) Approach*(Hussain and Ferneley 2008), *Towards the design of a quick and universal questionnaire to assess the intuitiveness of products*(Boisadan et al. 2021), and *Framework for Evaluating the Usability of Mobile Educational Applications for Children*(Tahir and Arif 2014). These paper has created guidelines that are useful when evaluating games or intuitive design.

2.3.1 Usability Metric for Mobile Application: A Goal Question Metric (GQM) Approach

Hussain and Ferneley has in this paper reviewed existing measurement models, further explained the development of usability metrics using GQM approach and developed a set of usability guidelines for mobile application which have been used to develop a metric for usability measurement.

Hussain and Ferneley produced their usability guidelines based on collected works from literature. They used three generic usability guidelines and the remaining guidelines are for mobile usability.

Then, Hussain and Ferneley had a four step approach to review the guidelines:

- Identify and combine duplicate guidelines.
- Identify and resolve guidelines that conflicted with each other.
- Reword unclear guidelines.
- Select the guidelines that comply with mobile devices only.

Furthermore, they wanted to determine the importance and appropriateness by marking each guideline as good, appropriate or not appropriate. The marking process was based on the question 'How important is this guideline to the success of a mobile application?'. The guidelines that were rated as having little importance to the success of a mobile application were eliminated. Lastly, a group of usability researchers, practitioners and authors were recruited to rate each guideline.

With the guidelines completed, Hussain and Ferneley created metrics for mobile usability guidelines using the GQM approach. GQM will be explained further explained in Section 3.4. After generating a complete set of metrics that assist in improving usability guidelines, the paper validated the model with two test cases by implementing usability tests on mobile applications.

2.3.2 Towards the design of a quick and universal questionnaire to assess the intuitiveness of products

This paper designs a tool to assess intuitiveness of products. Boisadan et al. found that existing scales showed some limitations when used by children or when evaluating non-digital products. The goal was to obtain a more universal questionnaire tool.

This research explores the INTUI(Ullrich and Diefenbach 2010) scale which measures the components of an intuitive interaction through 17 items. The components of intuitive interaction are:

- **Effortlessness**: intuitive interaction is fast and performed without cognitive effort.
- **Gut feeling**: intuitive interaction is guided by gut feelings.
- **Magical experience**: people get the feeling of living a magical experience and they refer to their interaction with expressions such as “incredible” or “extraordinary”
- **Verbalizability**: people are unable to verbalize the sub-steps conducted to achieve the goal of their task.

The INTUI questionnaire consists of 17 items/questions that that measures the four components of intuitive interaction. An example item is: *"[While using the product] it took me a lot effort to reach my goal / I reached my goal effortlessly"*, which is an item that measures the intuitive interaction component effortlessness. Boisadan et al. discovered multiple problems with INTUI:

- INTUI is too long for children.
- The vocabulary is too complex to understand.
- Children identified that there are redundancies between items
- Some questions were not adapted to non-digital products.

Boisadan et al. then revised the INTUI questionnaire and tested it on 40 children and 27 adults. The tests revealed that the intuitive interaction components "Effortlessness" and "Magical experience" were not reliable for children, only adults and that the "Verbalizability" dimension was not relevant at all. From these results the researchers then further revised the INTUI questionnaire, which now only contains 5 items.

Final INTUI revised.	
Effortlessness	[Q1] To[...]*:
	You did not know what to do at all
	You did not know what to do
	Between both
	You knew what to do
	You knew perfectly what to do
	[Q2] To do [...] was:
	Not easy at all
	Not easy
	Between both
	Easy
	Very Easy
Magical experience	[Q3] To do [...] was:
	Very common
	Common
	Between both
	Good
	Magical
	[Q4] To do [...] was:
	Very unfunny
	Unfunny
	Between both
	Funny
	Very funny
Intuitiveness	[Q5] To do [...] was:
	Not intuitive at all
	Not intuitive
	Between both
	Intuitive
	Very intuitive

*The space in square brackets is to be filled in with the task to be performed.

Table 1: The last revision of the INTUI questionnaire

2.4 Framework for Evaluating the Usability of Mobile Educational Applications for Children

When using mobile technology as a learning tool for children it is important that the interface of the application is usable and compatible with the cognitive skills of children, so that the children can have an effective learning experience. Tahir and Arif has in this paper created a framework for evaluating the interface of mobile educational apps designed for children. They start by reviewing the existing interface design guidelines, before developing the framework. Traditional usability measures are limited to metrics involving time to complete task, throughput, effort to complete task and the user's satisfaction, but researchers are now suggesting that these metrics are not enough for a mobile learning platform. These traditional approaches are missing the usability criteria. The usability criteria such as efficiency, reliability and consistency can be combined with pedagogical usability components like motivation, learner control, feedback and learner activity to improve the mobile learning experience.¨

Tahir and Arif's evaluation framework consists mainly of three phases. The first phase involves doing a literature review to find the usability characteristics and guidelines for interface design of educational apps for children. The second phase involves exploring the GQM approach to develop metrics for usability evaluation of mobile educational apps for children. The metrics developed from the GQM approach can be both objective or subjective. Lastly, in the third phase the metrics are separated into objective and subjective metrics which are then used to develop two measurement instruments. A task list and a questionnaire. These instruments can be used for usability evaluation

of mobile educational apps for children with the purpose of obtaining quantitative and qualitative data.

3 Theory

This section will explain all the necessary terminology that is used in this paper to provide a better better under stand the thought processes in this paper and to reduce ambiguity. This section will first explain what this paper has defined as a game, game mechanics and intuitive game mechanics. This is followed by an explanation of the GQM approach and then Don Normans' design principles will be explored.

3.1 What is a game?

"If we desire to understand games and game design, we must first clearly establish our fundamental orientation. We must define what we mean by the word 'game'."(Crawford 1997)

The definition of what a game is has changed a lot over time and morphs depending on the context where it is used. According to Wolfgang Kramer, the modern definition of a game comes from the works of Johan Huizinga and Friedrich Georg Jünger(Kramer 2000). They see a game as a natural phenomenon, but Kramer believes that their definitions are too wide and wants to describe games more succinctly.

Kramer believes that a game always has components and rules. Components are the hardware and the rules are the software. They exist independently from each other, but without both it is not a game. There are also certain criteria that a game must have. Game rules, goal, chance and competition. Game rules will be explained in the Section 3.2. Every game has to have a goal, whether it is a victory condition or requirement. Without a goal, a game will never stop and keep going on forever. The third criteria is the chance attribute, where a game involves some type of experimentation with chance that makes sure that the course of a game never stays the same, but this criteria is not relevant anymore. The last criteria is competition, which goes hand in hand with the goal criteria. If there is a goal to be completed then there is a competition. A competition doesn't have to be between two players. A competition can also be the player competing against one of the predetermined situations, which means the player competes against the game system itself.

This was a general definition of games, but what we are developing in this paper is a video game. The definition of a video game is mostly the same as what has been described above, but with the inclusion of game mechanics.

3.2 Game Mechanics

The definition of game mechanics is a little unclear. In Sicart's article about defining game mechanics(Sicart 2008), Sicart explains that seasoned players of video games would categorize a "mechanic" as something that connects the players´actions with the purpose of the game and its main challenges. But also used the game where players would consider the gravitational fields of the planets as a game mechanic to prove how unclear the concept of a game mechanic is, since this mechanic doesn´t fit in with the first definition of a game mechanic.

Sicart defines game mechanics, using concepts from object-oriented programming, as methods invoked by agents, designed for interaction with the game state. This incorporates a lot of new terminology that can be useful for analyzing game mechanics.

3.2.1 Methods

Object Oriented framework allows for analysis of game mechanics as available both to humans and artificial agents. A method is according to object oriented programming terminology, the actions or behaviors available to a class. By applying this terminology to game mechanics, we find that game mechanics are the actions an agent invokes to interact with the game world. This also allows us to map mechanics to input devices, as the player invokes a mechanic to interact with the game through input devices like a mouse and a keyboard. Thus, it could be argued that Don Norman's design principles apply to game mechanics, because the input devices act as interfaces for the players to interact with the game world. The same inputs from the same input device can be interpreted in multiple ways according the state of the game world. This leads into the next useful terminology which is contextual mechanics.

3.2.2 Contextual Mechanics

Contextual mechanics are game mechanics that are strictly associated with the context of the players presence in the game world. In other words, a single press of one button can be interpreted in multiple ways depending on what the player is doing in the game. For example pressing a button next to an item on the ground can allow the player to pick up the item, but pressing the same button next to a door can allow the player to open up the door. They are two very different actions, but both actions are mapped to the same button. This definition for contextual mechanics separates the game rules from the game mechanics. The game mechanics interacts with the game state, while the game rules provide the possibility space where the interaction is possible.

3.2.3 Game Rules

Game rules can be considered the general or particular properties of the game system and its agents. All game objects have properties that are rules or are determined by rules. In a game there exists a concept called a game loop, which is an algorithm that constantly checks for the state of the game world and its objects to determine if there has been met any conditions that could change the state of the game.

For this project, we wanted a measurement system that could help us determine the strengths and weaknesses of the current game mechanic prototypes that have been created. The Goal Question Metric(GQM) approach is a tool that can be used to define measurable goals for this project.

3.3 Intuitive Game Mechanics

What makes game mechanics intuitive in a digital game context?

In Section 2 a lot of definitions for intuitive interactions were explored. Ullrich and Diefenbachs' definition of intuitive interaction in Section 2.3.2 explained that an interaction that is fast and performed without cognitive effort, as well as an interaction that is guided by gut feelings. Hussain and Ferneley. In Section 2.2.2, McEwan explores Blackler and Hurtienne's definition of intuitive interaction, which is the correct action in the context of use, which can be much faster due to the increased speed of subconscious rather than analytical processing. Albert Quek and John See defined that a game mechanic is intuitive if the players were able to complete the game with minimal or no assistance, which was explained in Section 2.2.1.

The definitions explored are all very similar. They all agree on the fact that intuitive interactions are faster to complete in nature since they require less cognitive effort and without analytical processing. Therefore I will define the intuitive game mechanics as game mechanics that a player can understand and complete without the use of assistance or analytical processing.

3.4 The Goal Question Metric Approach

The approach was originally defined for evaluating defects for a set of projects in the NASA Goddard Space Flight Center environment. It was originally used to define and evaluate goals for a specific project in a specific environment, but has since been expanded to suit a larger context. Applying the Goal Question Metric approach will result in a specification of a measurement system that targets a particular set of rules for the interpretation of measurement data. This measurement model is split into a hierarchical structure of three levels called the conceptual level, operational level and the quantitative level.

1. **Conceptual level (GOAL)**

   This level defines a goal for an object according to the various models of quality. Some examples of measurements are:

   - Products: Artifacts, deliverables and documents.
   - Processes: Software related activities that usually are time based.

   Resources: Items Used by processes in order to produce their outputs.

2. **Operational level (QUESTION)**

   This level defines a set of questions that is used to characterize the way the assessment of the goal is going to be performed.

3. **Quantitative level (METRICS)**

   This level defines a set of data that is associated with every question in order answer it in a quantitative way. We have two forms of data, which are objective and subjective.

We start with a goal which is refined into several questions, which in turn are refined into several objective or subjective metrics. The metrics are then used to answer the same questions that they derived from. The same metrics can be used to answer multiple questions as long as the different viewpoints are properly taken into consideration when the measurements are being taken.

There are specific methodological steps to setting goals for the application of the GQM approach. A goal has the three coordinates, issue, object and viewpoint, as well as a purpose. We want to specify goals that takes into account the structure and the objective of the organization, which is done by basing the goal on three basic sources of information. The first source is the policy and the strategy of the organization, which will derive the issue and the purpose of the goal. The second source of information is the description of the process and products of the organization . The third source of information is the model of the organization, which provides us with the viewpoint.

With the goal in place we can derive meaningful questions that characterize the goal in a quantifiable way. This is usually done by asking questions that are categorized in three groups:

- Group 1. Questions that characterize the object with respect to the overall goal of the specific GQM model.
- Group 2. Questions that characterize the attributes of the object.
- Group 3. Questions that evaluate the characteristics of the object that are relevant.

With the questions in place we can create metrics that are associated with the questions. There are many factors to consider when creating metrics for the questions. Some of the factors to consider are the amount and quality of the existing data, maturity of the objects of measurement and the learning process. With the goal, question and metric developed, the GQM model is complete. The next steps are then to select the appropriate data collection techniques, tools and procedures. When the the data has been collected it will be mapped into the model and interpreted.

3.5 Don Normans' Design Principles

These design principles are derived from a mix of theory-based knowledge, experience, and common sense. They are written as a suggestion to designers about what to provide and what to avoid in interaction design. They are not complete guidelines that define how to actually define an actual interface, but act more like a check list to determine if the designers have provided certain features in the interface. There are numerous design principles that have been promoted over time, but this paper will only explain and list the once that are relevant for this project. These design principles are Visibility, feedback, constraints, mapping, consistency, and affordance.

3.5.1 Visibility

Users should be able to identify their options and how to get them by simply looking at an interface. Since it can be difficult to fit everything on the small screen of mobile applications, it is crucial to include only the options that are required. The more visible functions are, the more likely users will be able to know what to do next.

3.5.2 Feedback

Feedback is communicating what action has been taken and what has been accomplished. This is to let the user know if their actions were successful or not. For interface design, there are numerous feedback options, including audio, tactile, verbal, and combinations of these.

3.5.3 Constraints

This design principle involves restricting the users action by giving them less options. This is crucial because the user could be daunted by the variety of options shown by an interface. A constraint can be a phone number field on an online form that prohibits users from entering letters.

3.5.4 Mapping

The concept of mapping is that a well-designed product will have controls that closely mirror its result. The up and down arrows used to represent the up and down movement of the cursor on a computer keyboard is an example of good mapping.

3.5.5 Consistency

This refers to creating interfaces that perform similar operations and make use of comparable parts to do comparable tasks. A consistent interface adheres to rule. Similar looking interface elements should produce a similar effect. If a button on a website is designed as protruding boxes with labels on them, then every button on the website should be comparable.

3.5.6 Affordance

This is an attribute that an object can have that links how the object looks to how the object is used. An object with good affordance will let the user know how to use the object just by looking at it. A coffee mug has high affordance because it is obvious at a glance that the user should hold the mug by the handle.

4 Game Concept

The game is 2D mobile game where the theme is a "coming of age" story set in Norway. It will be a short game with a duration of around 45-60 minutes. The game combines the aspects of cartoons and mini games into one narrative driven game. Players are shown a board of illustrations and dialogue that they scroll through just like when they are reading cartoons on their phones. Smaller mini games will be implemented between the narrative sequences to prevent monotony for the players. The same mini games should show up later on in the story to communicate how the characters have evolved throughout the story. The games should always give the players a better understanding of the characters by how the characters are reacting to the events of the games by for example commenting on the different assignments or how they are completing the assignments. At least 50% of the game should consist of interactive mini games to maintain a fast tempo that keeps the player on their toes and hopefully prevent the players from losing interest in the story, but the transition from storytelling to gameplay should be seamless.

The game is developed using Unity (Technologies 2005) as the game engine. Unity is known as the go-to development environment for indie and mobile games and supports over 25 platforms from iOs, Android to PlayStation 4. The game mechanics are implemented using Microsofts' C(Microsoft 2001). C is heavily integrated with Unity, which allows for making variables in the C code and manipulating them in real time in Unity. This means that we can do things like manipulate the attributes of various game objects while the game is running to instantly get feedback on how these attributes affect the game.

Another important aspect of the game is to have as little tutorial and as few buttons as possible. As the game is built for the mobile game market it should be intuitive to play without a bunch of tutorials. It is important to have as few buttons as possible because buttons clutter up the screen which is detrimental to the player experience because of the limited space on a small mobile screen.

Figure 6 is an example of a storyboard where the player navigates through the story by scrolling through the panels with pictures and dialogue. The panels can come in from all directions. The player also has the option to scroll back if the player wants to read something again. The player scrolls to reveal new panels. It's important that the player always understands what is happening in the panels.

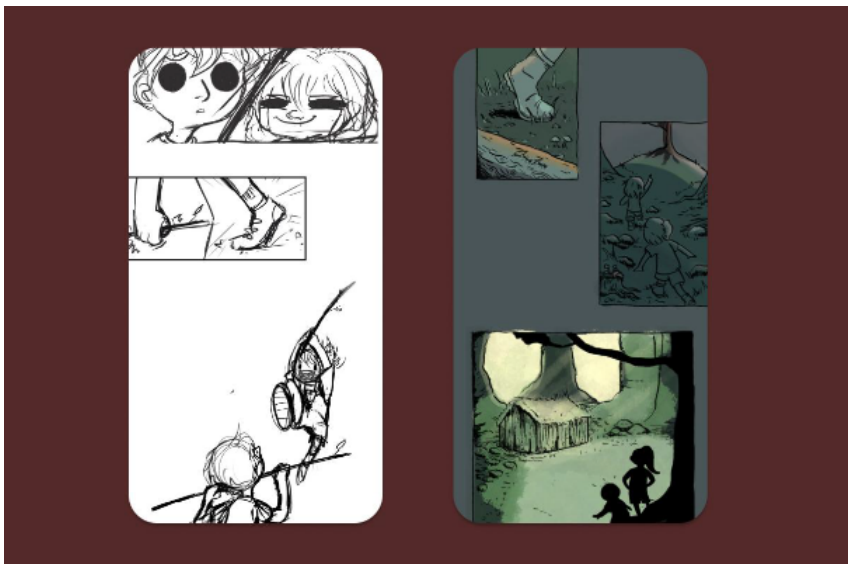

Figure 6: Example of a storyboard.

The interactions will vary widely. It is important that the interactions are intuitive. There should be no need for text boxes that tell the player what to do. The player should be able to figure this out on their own. It is also important that the mini-games build on what the characters are

feeling. They should be short (no longer than 15 seconds to complete) and the transitions between the panel sequences and the mini-games should be as seamless as possible. It is important that we are quick to prototype these and do not spend a lot of time polishing. The most important thing is that we quickly get them out to users by using resources that are already online, so that we can get feedback as fast as possible.

As seen in Figure 7, the leftmost picture presents a concept of a game mechanic where the player has to pan the camera over to the whole family before taking a photo. In the picture to the right is an example of a story telling sequence. Figure 8 shows a dialogue game mechanic where the player gets to choose which dialogue option the player wants the main character to communicate to the side character.

Figure 7: Screenshots from the Sami game.

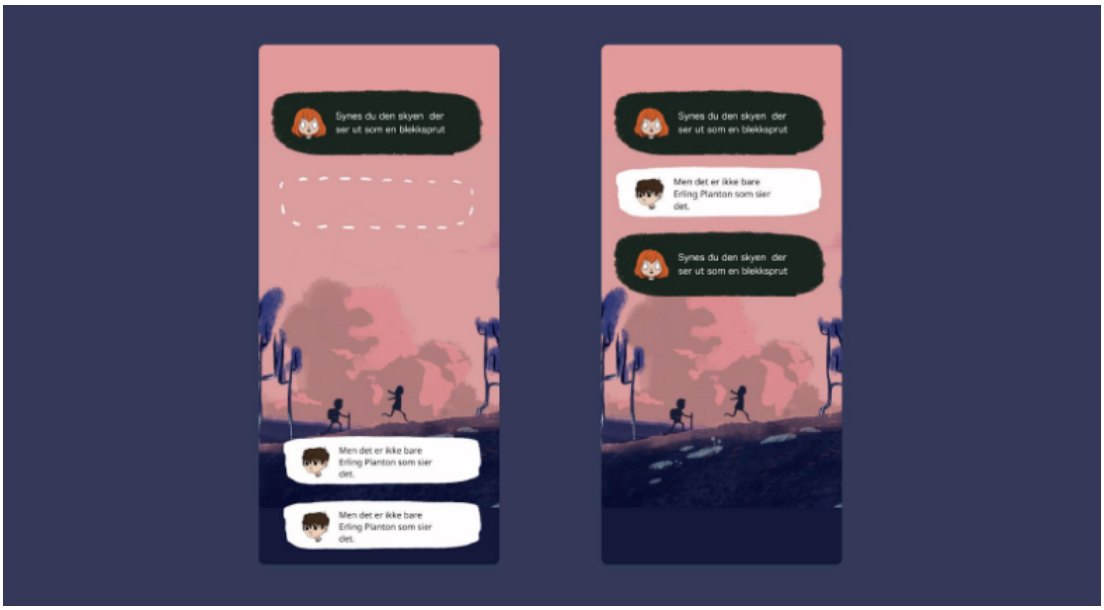

Figure 8: A game mechanic involving dialogue options

The art is characterized by expressive facial expressions that create fun/relatable moments as seen in Figure 9 and Figure 10. Blue and red are the main colors in use as seen in Figure 11. This is to

create a consistent look throughout the game. The colors are also used as recognizable elements for the game. The lines are a bit rough around the edges to make the characters feel more vulnerable. It also creates an interesting texture that makes the game feel more tactile.

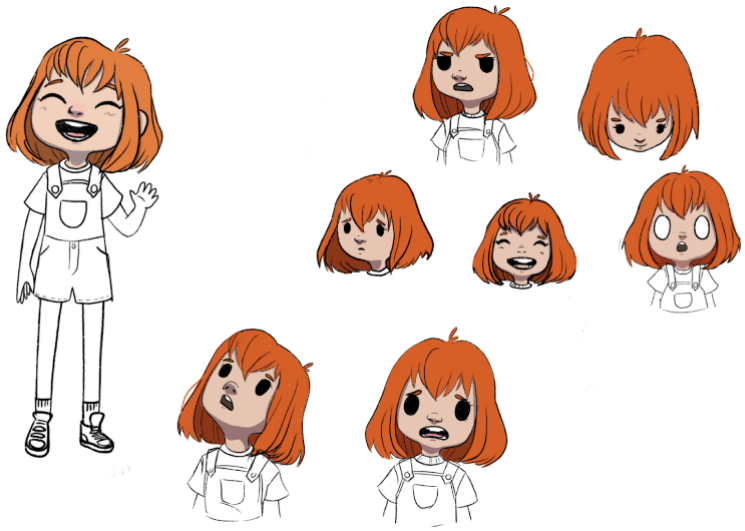

Figure 9: Character sketches for Inga

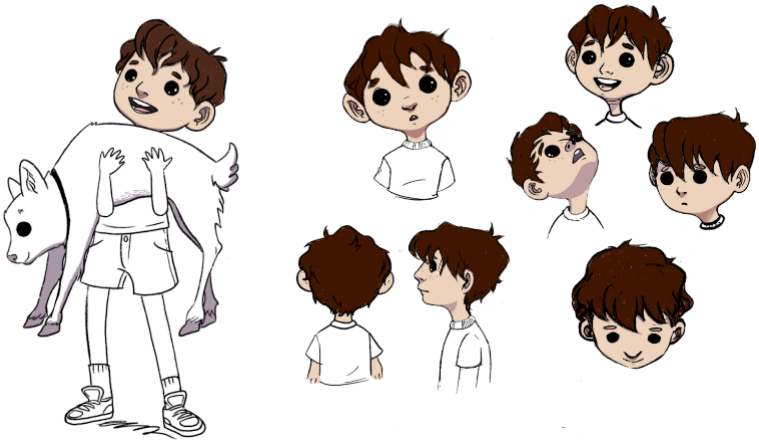

Figure 10: Character sketches for Noa

Figure 12 and Figure 13 represent how we have created art based on real environments or real Sami art. It is important that the game has its own visual art style, but at the same time based on real life to better engross the players in the story.

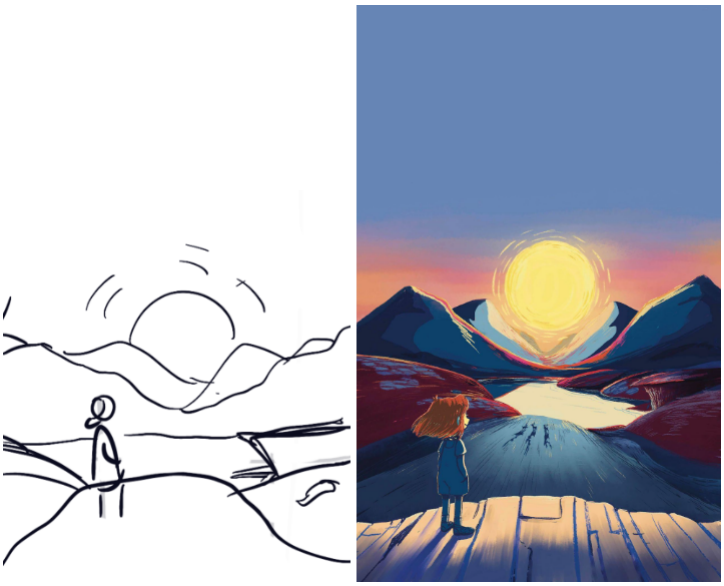

Figure 11: Example of a draft and a finished sketch

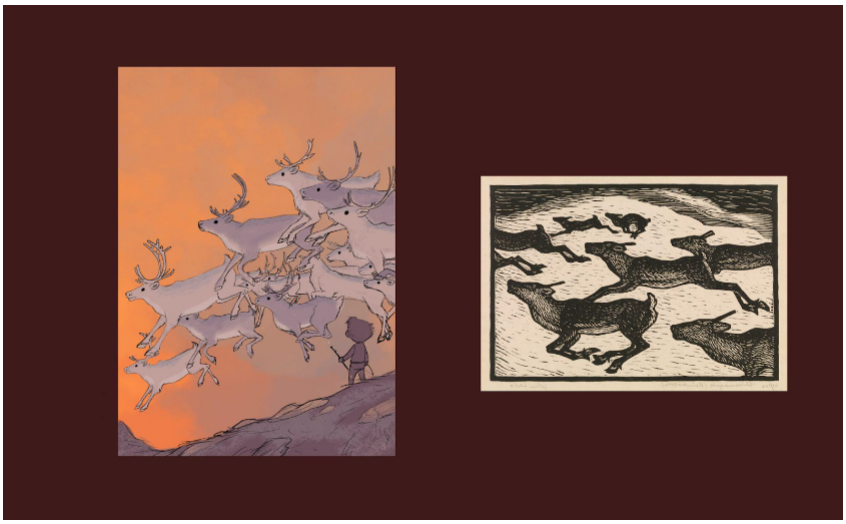

Figure 12: Our visual art style next to real Sami art

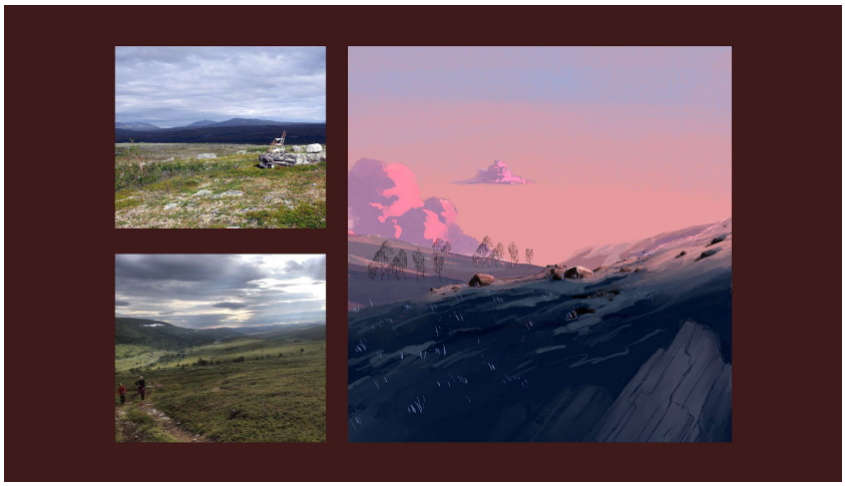

Figure 13: Our sketch next to real locations

The music should reflect the main characters of the game. Both characters (Noa and Inga) should have their own melody, represented by their own instrument. When, for example, a sad version of Noa melody is played, this will reflect how he feels. In other scenes, we want a nostalgic mood. Then it is important that the music reflects this. The game will have relatively few animations, and it is mainly sound that will communicate movement and mood.

5 Research Methodology

This section seeks to explore the research questions that were mentioned in Section 1. Firstly, the game mechanics that have already been developed and tested by myself and the design team will be studied and analyzed to see how the design teams use of Don Normans' design principles affected the final product. Secondly, the prototypes that will be tested in the user evaluation will be presented. Lastly, the user evaluation procedure will be explained.

5.1 Completed game mechanics

There are three standout completed game mechanics that have undergone testing and have achieved good results in the tests. These are the line tracing mechanic, reveal mechanic and dialogue mechanic.

5.1.1 Line tracing mechanic

The line tracing mechanic is a game mechanic where the player drags their finger along dots to trace a line from one dot to another, as shown in Figure 14. The game always starts from the top left dot and follows the dots to the right. This is done to achieve consistency between games, since the user always follow the same path. This also achieves constraints by not allowing the user to trace the lines in another direction.

The mechanic has undergone three iterations, but one is not shown in the figure. The first iteration is shown in the leftmost picture and shows all of the dots from the beginning. The challenge with this design is that the user becomes overwhelmed by all of the dots and has no idea about where to start, which means the design has poor visibility. The second iteration numbers all of the dots so it is more obvious where the user has to begin and the direction to trace in. It also mimics the "connect the dots" game, but the problem with this design was that a mobile screen is too small and the large amount of numbers end up cluttering the screen too much. That is why the last iteration removes all of useless dots and only reveals a dot when the player has to connect a line to it. This improves the visibility a lot.

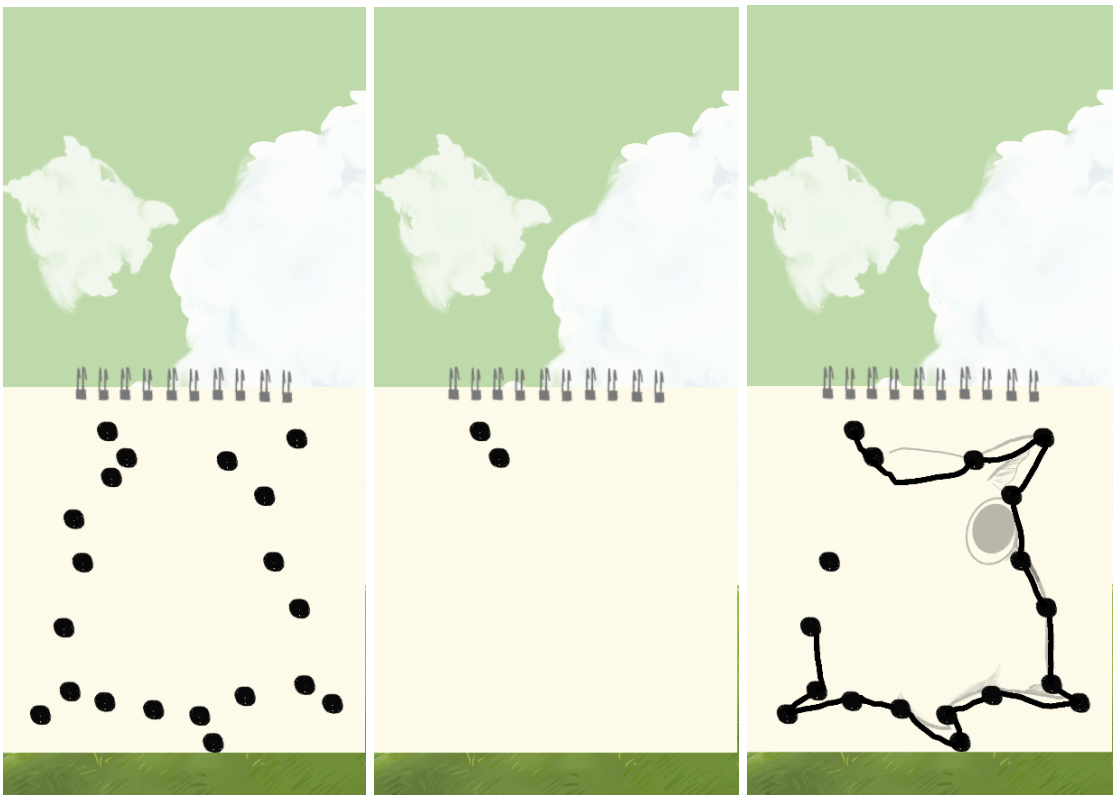

Figure 14: Screenshots of the line tracing mechanics before and after revision.

5.1.2 Reveal Mechanic

The reveal mechanic is a game mechanic where the user drags their finger over the paper which slowly reveals the drawing underneath, as shown in Figure 15. To complete the game, the player has to reveal enough of the picture before the whole picture reveals itself to the player.

This game mechanic did not have any revisions because initial user testing instantly got great reviews and feedback. The developer team and designers believe this is because of good visibility, feedback, mapping and affordance. The visibility is good in the game mechanic because it's just a piece of paper on a background. This makes it obvious for the player that they should put their finger on the piece of paper. It is also obvious that if the user traces their finger on the piece of paper, then something should happen to the paper, which means that the mechanic has good mapping and affordance.

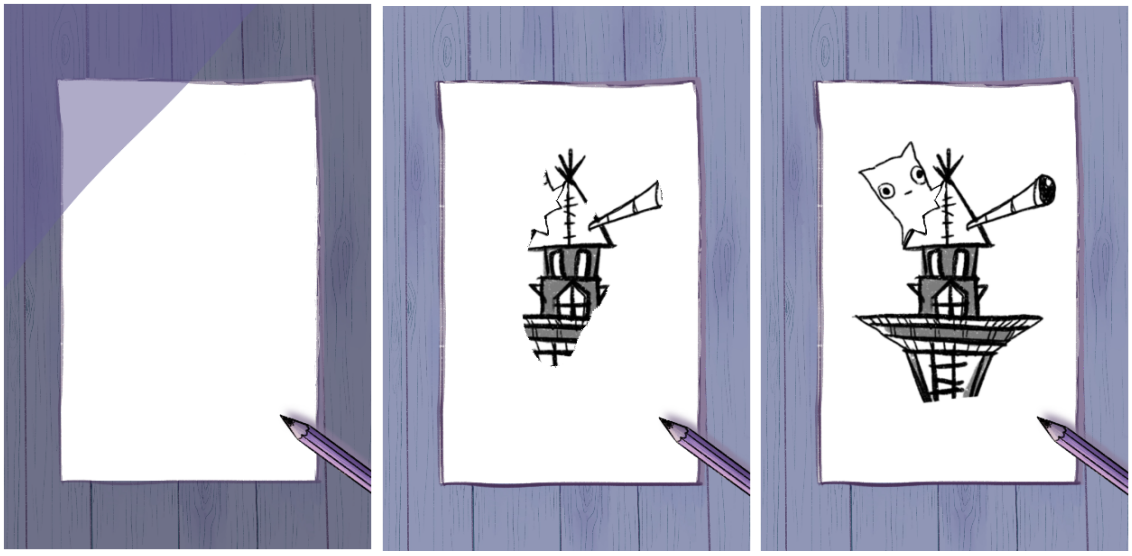

Figure 15: Screenshots from the reveal mechanic.

5.1.3 Dialogue Mechanic

This simple game mechanic as shown in Figure 16, involves dragging a dialogue option and dropping it inside the dotted lines. The player will get a different answer depending on the option that they select.

This dialogue mechanic has been revised once. The dotted lines were not yet implemented in the first iteration and the player only had to click on the dialogue option that they wanted to select. This iteration did not have any problems relating to Don Normans' design principles. The players seemed to understand what to do to complete the game mechanics within seconds of viewing, but some players accidentally picked a dialogue option they did not want. To fix this problem we made the current iteration where the player has to drag the dialogue into the slot instead of just clicking on the dialogue option. This gives the players more leeway to make mistakes without consequences, since they dialogue option will just go back to it's original position if the player drops the dialogue outside of the dotted lines.

Figure 16: Screenshots from the dialogue mechanic.

5.2 The Prototypes

In this paper we are testing three prototypes of game mechanics, a calendar mechanic, an envelope mechanic and a mechanic for the paper inside the envelope. These game mechanics are developed based the experiences from previous game mechanics that we have made like the the game mechanics in Section 5.1, the Don Normans' design principles and based on Section 2.2.2 where McEwan explored that a product has a high potential for intuitive use if it is designed to take advantage of experiential knowledge that is broadly possessed by the target audience. By creating the game mechanics based on real life actions and objects, the players will already be acquainted with how the game mechanic should work. We have also made sure that there is a proper level of constraint in the mechanics by making sure that only game mechanics can be interacted with. The game mechanics are also all very short and thus a proper level of feedback should be achieved as something happens with game mechanic as soon as the player interacts with it.

5.2.1 The Calendar Mechanic

This game mechanic is copies a calendar where the user has to rip the paper at the seams to reveal the next date underneath, as shown in Figure 17. The picture over the calendar changes every time a calendar page gets ripped off and this game mechanic is made to show the passing of time. The goal of centering the calendar on the screen and having bolder borders on the calendar is to improve visibility. The dotted lines are supposed to simulate a seam where the paper is supposed to be ripped, which should improve visibility and affordance. Affordance and mapping should be high in this game mechanic because ripping the paper off simulates how the player would actually do the action in real life.

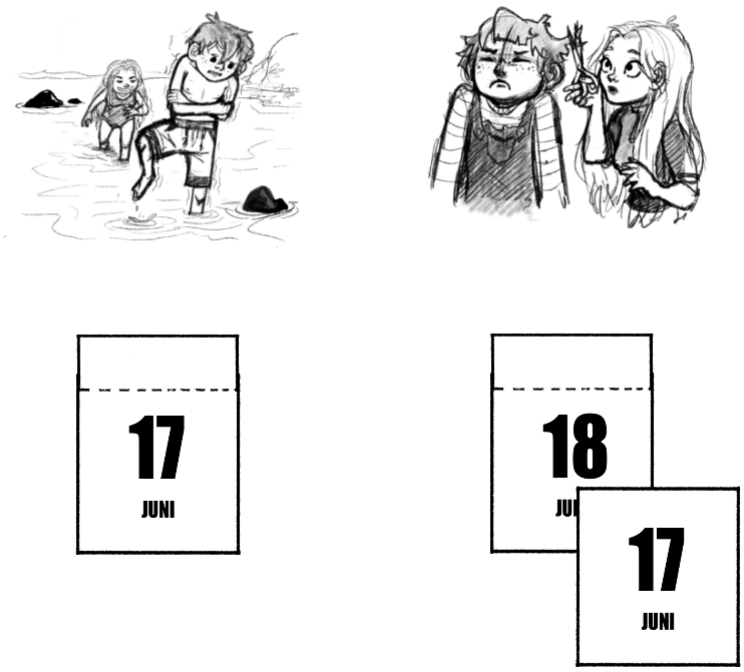

Figure 17: Screenshots from the calendar mechanic.

5.2.2 The Envelope Mechanic

This game mechanic simulates the function of an envelope. It is a very simple game mechanic where the player has to open the top flap to reveal the contents that are inside the envelope. The player opens the flap by first holding their finger on the flap and then by performing a dragging motion upwards the flap will rotate with the players finger to reveal the contents of the envelope underneath.

High visibility is achieved by not having anything around the envelope that could distract the player and by having the top flap overlap all the other folds of the paper envelope. Similarly to the calendar mechanic, mapping and affordance is achieved because the gaming mechanic simulates an object and an action that most people have familiarity with.

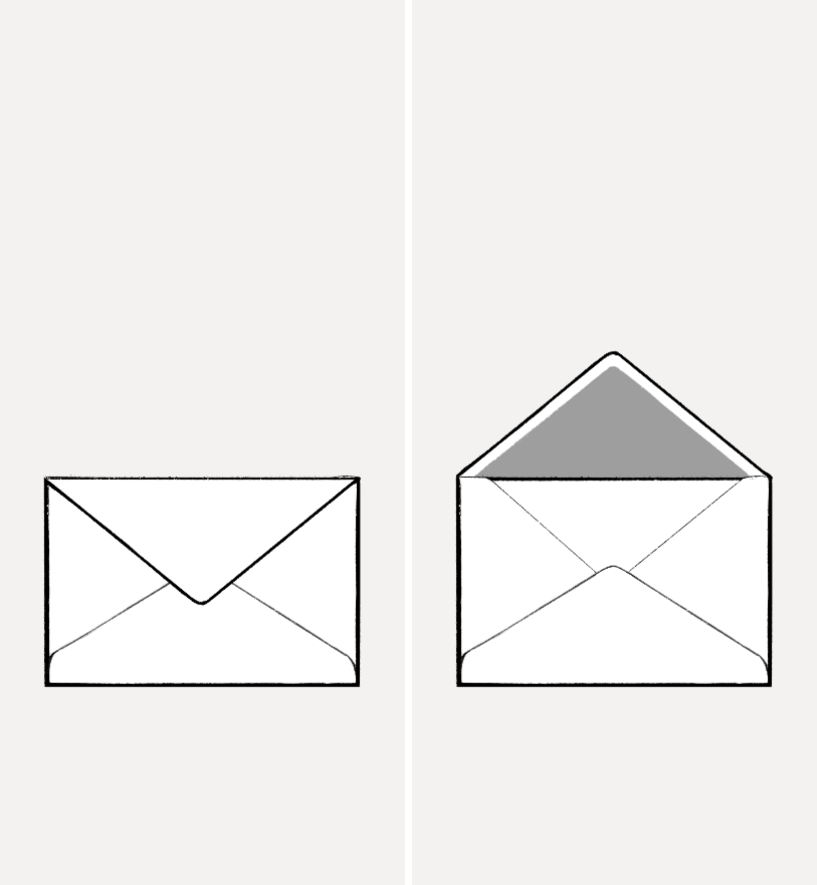

Figure 18: Screenshots from the envelope mechanic.

5.2.3 Envelope Content Mechanic

The envelope content mechanic is simplest mechanic that will be tested. The game mechanic is completed by moving the contents of the envelope to the outside. This is done by touch the paper inside and dragging it outside of the envelope in an upwards motion, which is exactly the same movements as the envelope mechanic. Having two different mechanics that both simulate actions performed on paper, but at the same time simulating two different actions on two different objects, being completed by doing the same movements provide consistency between the mechanics as well as providing different feedback. Otherwise affordance and mapping should be on the same level as the other mechanics in this section.

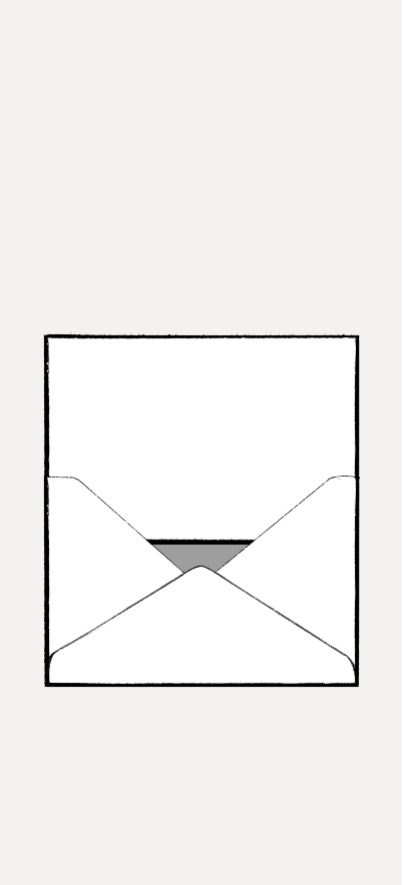

Figure 19: Screenshot from the envelope content mechanic.

5.3 Evaluation Framework

The evaluation framework is inspired by the research papers that were discussed in Section 2.3 and will be used to measure how intuitive interactions of the game mechanics for 2D games on the mobile phone. Like in Section 2.4, the framework consists three phases. The first phase which was explored in Section 2 is the literature review work that has presented the definition for intuitive interaction as well as guidelines for intuitive design.

The second phase involves developing metrics for intuitive interaction evaluation of the prototypes. Similarly to Section 2.3.1 and Section 2.4, the metrics are developed using the gqm approach developed by Basil et al., which was presented in Section 3.4. The goals and questions were inspired by the GQM model explored in Section 2.4 and the Revised INTUI questionnaire from Section 2.3.2. Lastly, the metrics are separated into objective metrics that are used to develop the task list and subjective metrics that are used to develop the questionnaire. These measurement instruments will be used to evaluate the intuitiveness of the game mechanic prototypes presented in Section 5.2.

5.3.1 The goals, Questions and Metrics

The information derived from the literature review in Section 2.3 has been used to create the goals of the GQM model. The goal represents the overall aim of evaluation when the user tests are performed with the prototypes.

The goals and guidelines were then used to create a list of questions and then the questions were used to develop the objective and subjective metrics, since it was not possible to answer all of the questions with only objective metrics. That is why the answers to the subjective questions

will be collected using a questionnaire. The finished GQM model is shown in Table 2. The GQM model will then be used in the last phase of the evaluation framework to develop the evaluation instruments.

Intuitive interaction components	**Goals**	**Questions**	**Metrics**
Effortlessness	Efficiency	How quickly can the users perform the tasks?	Time taken to complete the game mechanic
		How difficult was it to complete the game mechanic?	Time taken to find and click on the game mechanic
			Time taken to complete the first task of the game mechanic
			Rating scale for the game mechanics perceived difficulty
	Visibility	Was it easy to see where the interactive part of the mechanic was?	Number of times the user tried to interact with something that wasn't the game mechanic
			Time taken to find and click on the game mechanic
			Rating scale for how easy it is to find the interactive part of the game mechanic
Magical Experience	Satisfaction	Was the game mechanic enjoyable?	Rating scale for enjoyment
Intuitiveness	Intuitiveness	How intuitive was the game mechanic?	Rating scale for intuitiveness

Table 2: The GQM model for interactive game mechanics.

5.3.2 Evaluation Instruments

In this section the subjective and objective metrics from phase two of the evaluation framework has been used to develop the two evaluation instruments, which are the task list and the questionnaire. These instruments are shown in Table 3 and Table 4.

The tasks are developed from the objective metrics to collect objective data and the questionnaire was developed to collect the subjective data like ratings of how well the users enjoyed the mechanic. These instruments can be used to perform intuitive interaction evaluation for game mechanics by assessing the subjective measures using a questionnaire and implementing tasks performance for the objective measures.

When using the intuitive interaction questionnaire, the participants are asked to rate the items related to intuitive design on a scale that ranges from 1 to 5. The meaning of the scale changes depending on the item and context. When asked how intuitive the user thinks a game mechanic is then a 1 is not intuitive at all and 5 is very intuitive, but for a difficulty rating then a 1 is very easy and 5 is very hard.

The complete framework offers a comprehensive structure for evaluating intuitive game mechanics in video games. It describes to what degree the game mechanics has achieved proper intuitive interaction and how these can be linked to interactive design principles. This makes the framework useful for obtaining data both qualitative and quantitative data for interactive game mechanic evaluation.

The tests were performed on a total of 15 adults ranging from age 19 to 33. In the paper explored in Section 2.4, it was mentioned that a minimum number of eight to ten participants are generally required in order to make reliable estimates to uncover the usability problems of an interface. The participants included a mix of males and females from different backgrounds.

Task list
1. Check for visibility a) Check how many times a user tries to interact with something other than the game mechanic b) Check the time spent before the user touches the game mechanic
2. Check for intuitiveness a) Check the time spent before the user understands the game mechanic b) Check the time spent before the user completes the game

Table 3: Task list.

Intuitive Interaction Questionnaire
1. The game mechanic was difficult to complete
2. It was easy to find the interactive part of the game mechanic
3. You found the game mechanic to be enjoyable
4. You found the game mechanic to be intuitive

Table 4: Questionnaire

5.4 User Study

To determine if applying Don Normans' principles when creating game mechanics have been successful in creating an intuitive experience a user study was carried out. The evaluation instruments (questionnaire and task list) and the metrics developed in the framework are used to collect the data for the intuitive interaction evaluation. Both the metrics and the evaluation instruments were used on all three prototypes shown in Section 5.2 on players of mainly the college age group.

All of the prototypes are coded to store the data which are the objective metrics in the application itself as shown in Figure 20. The application gathers the data in two ways. The first method is time based and implements a hidden stopwatch that times when the user first touches the game mechanic, when the user completes a task and when the user has completed the game. The second method counts all of the times the user clicks on something that isn't the interactive mechanic. When the user has completed the test, the data will be automatically uploaded to an excel spreadsheet where the averages of the data will be calculated and stored.

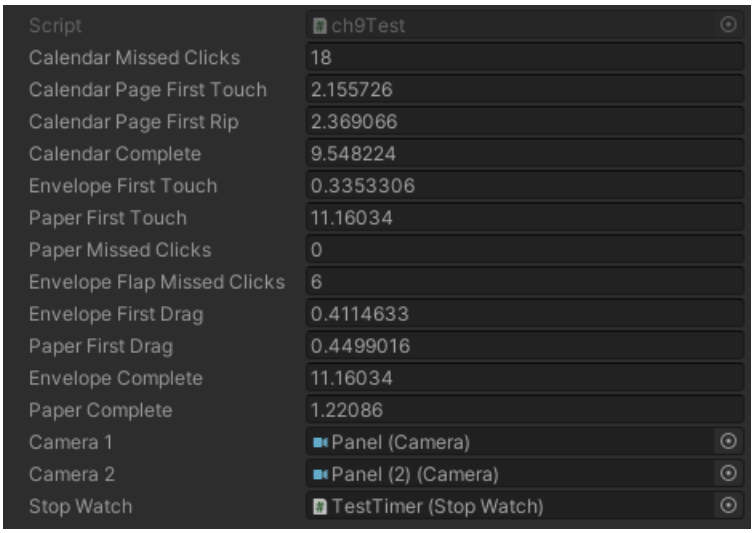

Figure 20: Screenshot from the data collected from a user test performed on the Unity client.

The tests were done by first uploading the application to google drive before sharing the application with the users. This is done to be able to perform testing on users that are not nearby. As seen in Figure 21, the application has a starting screen that informs the user of the purpose of the test and what we have defined as intuitive game mechanics. This is done to make sure that the user is not confused about the meaning of intuitive game mechanics when filling out the questionnaire. When the user has completed the test they will be prompted to fill out an online survey/questionnaire that have been given to them together with the application, which can be seen in Figure 21.

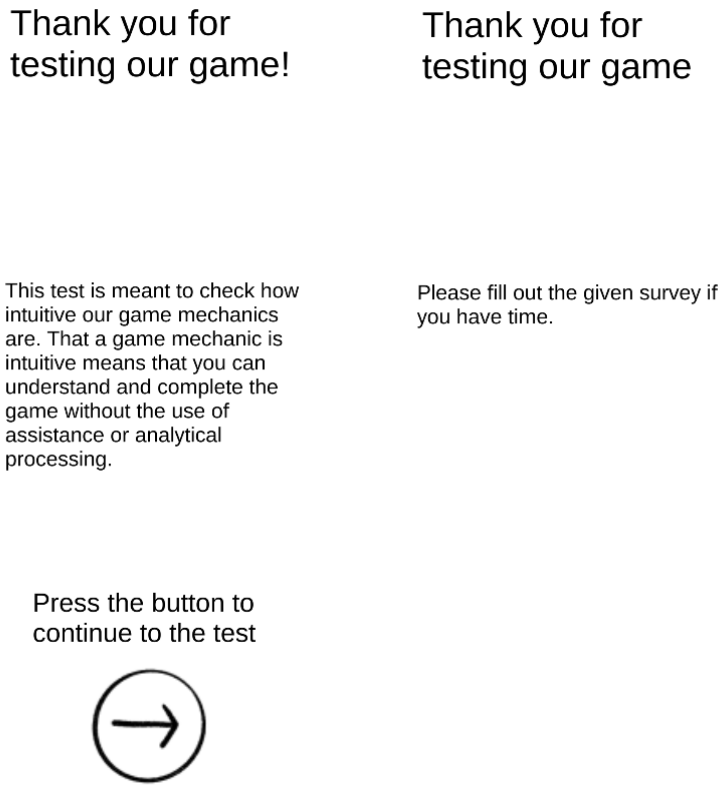

Figure 21: Screenshot of the front- and end pages from the test application.

6 Results

In this section the data from the user evaluation has been collected and the mean values have been calculated. The objective results and subjective results will be presented separately and the mean values of the different metrics will be compared between the prototypes. This is done to check for significant differences in intuitiveness between the game mechanics, but the most important.

6.1 Objective Results

The data for the objective metrics were as explained in Section 5.4, collected automatically through the application. There was a total of four objective metrics that were collected from each prototype and the data was then summarized. The mean score for each measure is presented in Table 5 for each game mechanic that has been tested.

By comparing the results it is instantly recognizable that the most significant differences between the prototypes are in O4. The mean value for the calendar mechanic is significantly higher than the other game mechanics. Otherwise, the envelope mechanic seemed to perform significantly worse than the other prototypes. The calendar mechanic and paper content mechanic performed very similarly for the metrics O1-O3.

Objective Metrics	**Calendar Mechanic Mean**	**Envelope Mechanic Mean**	**Paper Content Mechanic Mean**
O1 - Number of clicks outside of the game mechanic	2.5	10.5	0.5
O2 - Time spent before the user touches the game mechanic	3.7	4.5	3.6
O3 - Time spent before the user understands the game mechanic	3.9	4.8	3.8
O4 - Time spent before the user completes the game	39.1	15.9	2.3

Table 5: Result for Objective Metrics

6.2 Subjective Results

The data for the subjective metrics were collected using a survey/questionnaire after the players completed the user test. The participants scored the prototypes based on the subjective metrics through a scale from 1 to 5. Then the data was summarized into mean values and the data was analyzed and compared between the game mechanics. The data from the subjective metrics are shown in Table 6.

From the results it is shown that calendar mechanic was the most well received, getting a perfect score in intuitiveness and a positive score for all of the other metrics. The envelope mechanic performed very poorly compared to the other prototypes, which mirrors the data from the objective metrics. Users found the envelope mechanic to be very difficult to solve and not enjoyable at all, but rated the game mechanic highly in visibility. Lastly, the paper content mechanic scored very well for S1, S2 and S3, but scored very low in enjoyment.

Subjective Metrics	Calendar Mechanic Mean	Envelope Mechanic Mean	Paper Content Mechanic Mean
S1 - Rating scale for difficulty	2	4.5	1
S2 - Rating scale for easiness to find the interactive part of the game mechanic	1	1.7	1.1
S3 - Rating scale for enjoyment	3.9	1	1.6
S4 - Rating scale for intuitiveness	5	3	4

Table 6: Results for Subjective Metrics

7 Discussion

The results for the envelope mechanic was the most interesting to analyze as it performed the worst overall in the tests. Unfortunately we discovered that there was a problem with the envelope mechanic when the users tried to open the envelope quickly (which most people tried to do). This makes the the data collected for the envelope mechanic faulty and that is why this discussion section will mainly focus on the two other game mechanic.

7.1 Objective Results

The objective metric O4 had the most variance between the prototypes. This is because every game mechanic is different, which means that the game completion time will obviously vary a lot. The calendar mechanic just as simple as the other mechanics, but the user has to interact with the game mechanic more times to complete the game than the other game mechanics. This means that comparative analysis between the completion time of different game mechanics is not very useful.

The calendar mechanic and the paper content mechanic both performed very well on the other metrics. Both game mechanics has barely any difference in scores between metrics O2 and O3. This indicates that the participants' first interaction with the game mechanic was the correct action, which means that the participant instantly knew what to do to solve game mechanic. The mean values for O1 were also very low, which indicates that the participants knew that trying to interact with other parts of the screen other than the interactive game mechanic was the wrong thing to do. This means that based on the objective metrics, both game mechanics scored highly on the intuitive interaction component effortlessness, which shows that the game mechanics are indeed intuitive.

The metric O1 and O2 translates to the design principle visibility and O3 translates to mapping and affordance. As explained in Section 5.2, there was a heavy emphasis on the design principles visibility, mapping and affordance. The mean value of the data from the objective results show that heavily emphasising on visibility, mapping and affordance has given good results in intuitiveness for the game mechanics.

7.2 Subjective Results

The metric S1 translates to the intuitive interaction component effortlessness, where every mechanic scored positively except for the envelope mechanic but this result was faulty as explained in the previous section. S2 translates to the design principle visibility and the participants rated this metric highly, which means that all of the game mechanics have good visibility. The rating scale for enjoyment S3, translates to the intuitive interaction component magical experience, but not to any design principles. This means that there is a disconnect between the INTUI intuitive interaction component and Don Normans' design principles.

Both Don Normans' design principles and INTUIs' intuitive interaction components seek to break down intuitiveness in a product in separate components. The intuitive interaction component magical experience is not reflected in Don Norman's design principles. The various design principles are not concerned about giving the user a feeling of awe or enjoyment. This means that the magical experience component is not relevant for intuitive design according to Don Normans' design principles. When this information was brought up to the developer and design team, it was decided unanimously that the magical experience component would not be taken into consideration for intuitive interaction in future tests.

Most of the participants rated the prototypes highly in intuitiveness. This result combined with the objective results, shows that (at least for these mechanics and this game genre) focusing on Don Norman's design principles when designing the prototypes have yielded great results in intuitiveness.

8 Conclusion and Future Work

In this paper I have worked with a design studio to create an evaluation framework for 2D mobile games to test how intuitive the game mechanics are. The paper reviews games that have achieved the goals of our game, as well as other research that has explored intuitiveness in game mechanics and research on current practices for measurement models. By reviewing other similar research papers, it was discovered that the GQM approach was very popular framework. The GQM model that is developed using the GQM approach was a very useful tool to create good measurement instruments like questionnaires and task lists.

The framework developed in this paper is not a comprehensive structure for evaluating intuitiveness in game mechanics. This is because of issues like incompatibility between the INTUI intuitive interaction components and Don Norman's design principles and some metrics were not that valuable for intuitive interaction testing, like the objective metric O4 - time spent before the user completes the game. The other time based objective metrics and number of mistakes were very useful in determining intuitiveness in a game mechanic, especially because they can be correlated to the design principles.

The results have shown that focusing on Don Normans' design principles during the design phase of a 2D mobile game mechanic. For these prototypes the design principles visibility, mapping and affordance has been especially emphasised, which was reflected positively on both objective and subjective metrics. This highlights some of the directions for future work.

As mentioned in Section 1, there is not a large body of work for intuitive game mechanics and how to make them. There is also not a lot of papers discussing the combination of design principles for intuitive interfaces and game design. More work can be done to create a more comprehensive framework for evaluating intuitiveness in game mechanics. By focusing on other design principles in designed tests, other objective and subjective metrics can be discovered.

Furthermore, a comparative analysis test between two game mechanics where the design principles have been applied to only one of them can yield even more data on the benefits of applying interface design principles to game design. This can be done by testing the intuitiveness of a game mechanic where the design principles haven't been applied yet, then revising the same game mechanic using the design principles before testing for intuitiveness again.

Future work should also focus on expanding the validation of the framework by applying the research methodology in this paper to games of other genres and platforms. This will make the framework for intuitive game mechanics more reliable to be used by game developers to test the intuitiveness of their games.

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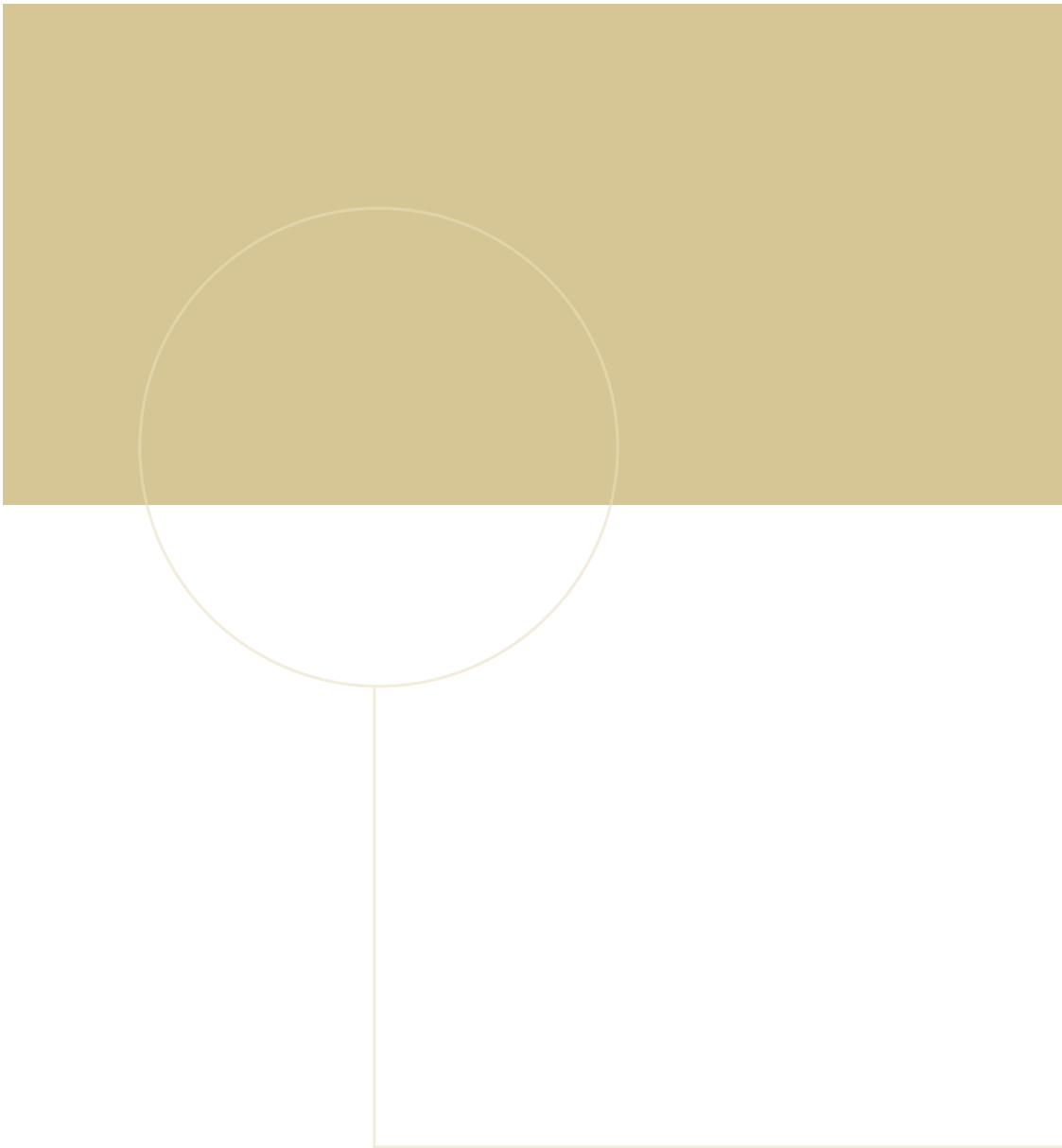

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