

Designing Mobile Augmented Reality Board Games

Exploring the Design Space With Regard to Player Engagement

Master's thesis in Interaction Design and Technologies

LUDVIG ARLEBRINK & CHRISTOPHER BLACK

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover: Markers used for AR tracking.

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Abstract

Augmented reality board games is a relatively new concept. Designing these types of games can be challenging for designers as there are no well established guidelines to consider. The combination of board games and augmented reality creates a large new design space for designers to explore. This thesis is concerned with exploring how to create player engagement in this new design space, as player engagement is a fundamental element of game design. Augmented reality can take many forms such as headwear or mobile devices. However, headwear is rather inaccessible to the general consumer, meanwhile mobile augmented reality is highly accessible via smartphone devices. In this thesis we explore player engagement regarding mobile augmented reality board games. We took a look at industrial practices and concerns, as well as current literature. We have built a board game using mobile augmented reality technology, which a set of experts evaluated. The results are a set of considerations for developers to keep in mind when developing mobile augmented reality board games.

Keywords: augmented reality, board games, gameplay design, player engagement, user experience.

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1

Introduction



Figure 1.1: The board game X-Com played at the game developers conference, 2016.¹

Augmented Reality (AR) is a concept for technologies that extend real-world information with artificial information. Not to be confused with *Virtual Reality* (VR), where all information is artificial. A well established and scientifically relevant definition of AR systems was provided by Ronal T. Azuma as having three characteristics: Combining the real with the virtual, being interactive in real-time, and being registered in 3D [3]. AR has seen a lot of growth over the last few years, as the technology is highly available to consumers through mobile devices. The typical consumer usage of AR is often contained in the domain of face tracking of arguably nonsensical photo filters, for instance, adding virtual mustaches to photos and videos. This is possible through the image recognition and tracking capabilities

¹Figure source: <https://www.flickr.com/photos/officialgdc/16674395726>. Photo taken by Official GDC and is licenced under the Creative Commons Attribution 2.0 Generic license: <https://creativecommons.org/licenses/by/2.0>

of modern smartphones and tablets. There are more sophisticated AR devices, e.g. the *Magic Leap 1* [46] or the *Microsoft HoloLens 2* [44]. However, due to the rather high pricing of these devices, they are not highly accessible for the general consumer.

What this thesis is concerned with is *Mobile AR* (MAR) board gameplay design. Although the market for digital games has increased massively over the last decades, we would argue that board games are still relevant, as they provide an inherently social, face-to-face experience, as can be seen in figure 1.1. As the relatively consumer friendly *Tilt Five: Holographic Game System* AR system which is specifically catered towards board games well surpassed its kickstarter goals, there seems to be a general interest of adapting board gameplay design to AR [60].

For this thesis, we are looking at current research, industrial problems, and concerns. Keeping these concerns in mind, we will create a prototype of an AR board game. Using a qualitative approach, we will have users to test our prototype, and then conduct interviews.

1.1 Purpose

As the area of AR board games is a rather new area, there are no well-established guidelines for designing these types of games as of yet. Since *Tilt Five: Holographic Game System* is in development and has a niche target group, this thesis is more concerned with readily available AR devices, namely smartphones. While smartphones may not be the technically most adapt devices for producing AR content, they are widely accessible and therefore being able to design for these devices is of interest for developers. For this reason we decided to focus our research on the development of AR games for mobile devices, such as smartphones and tablets.

There are already several AR games available for mobile devices. The most popular of these games that utilize AR is *Pokémon GO*. *Pokémon GO* is a location-based mobile game with AR features. However, the game can be played without AR and according to a study related to the success of *Pokémon GO*, most players do not play it with AR mode enabled [51]. The authors' of this paper mentioned that several game guides suggested having AR mode turned off, since it made catching *Pokémon* easier. This makes the AR a non necessary feature, and more of a gimmick. However, the authors' argued that it still may be an important novelty feature for new users when first picking up the game.

The purpose of this thesis is to give guidance to developers in regards to AR board gameplay design. Further, as in the case with *Pokémon GO*, avoid the usage of AR as a noncontributing gimmick.

As rather recently explored by Dirin and Laine there are a lot of challenges and research to be done regarding user experience (UX) design in MAR in general [14]. Dirin and Laine name specifically the modelling MAR content interactions, sustainable use through appropriation of MAR experience lengths and further studies of MAR experiences in various contexts to draw universal MAR UX guidelines as research areas, which are all topics this research is touching upon.

1.2 Goals and Challenges

For this thesis we are specifically looking at player engagement in regards to MAR board games. Ultimately, our goal is to generate consideration guidelines for MAR board game development, for gameplay designers to use. As player engagement is a loosely defined term, what we are referring to is active versus passive participation in an activity. As when a player is actively participating in an activity, the player is engaged. In the case of board games, we mean taking an active part in decision making, and being invested in the outcome of the game, rather than playing the game just for the social aspects. Active participation, engagement, is very often something a game designer wishes to achieve, and therefore we argue that engagement is a fundamental concept when analyzing new ways of playing games. Player engagement is deeply connected to the emotional experience of a player. Regardless of whether the experience is positive or negative, player engagement is an important factor of every player experience [6].

As with every design question, the question we pose also deals with a wicked problem [7]. As a wicked problem there cannot be a trivial solution to it, as there is not one right answer, but multiple answers. From these answers there may be some that solve the issue in a better, worse or just a different way.

Furthermore, this thesis aims to incentivize future work in regards to board games and AR development as the AR technologies are rapidly evolving.

1.3 Research Question

Ultimately this thesis should answer the following research question:

What should be considered when designing a board game, which utilizes mobile augmented reality, with regards to player engagement?

1.4 Approach

The approach for this thesis is to identify common issues with developing AR games by researching previous studies, and industrial practices. Based on this research a gameplay design will be developed along with a physical prototype with a MAR application. The prototype will be used to conduct user tests. The gathered data will be used to formulate the design consideration guidelines for designing MAR board games. A detail version of the approach is described in chapter 4.

1.5 Ethical Considerations

Regarding the design of the board game there are many things we need to consider. For instance, we do not want the board game to in any sense encourage misbehaviour among the players. For this we need need to look at negative aesthetics [45].

The aims of game designers and the players do not align sometimes. This may lead to a game not fulfilling the needs or wants of the player, or potentially even

harm them. Depending on the context of the game, mostly in role playing games, negative experiences can be intended and perceived as positive [49]. Providing an intentionally negative experience, can be considered ethically questionable. Design patterns that result in negative and potentially harmful experiences are sometimes referred to as *Dark Game Design Patterns* [64]. We are aware of the existence of these kinds of designs and will consider them when creating our design, as we do not intend to potentially harm the users in any way.

Another consideration that has to be taken into account when designing a game is that every play session takes place within a magic circle [53]. Especially since we are extending the traditional board game play with MAR features, which can result in activities which could be considered untypical for board games. Playing a MAR board game with this extended magic circle, situations may arise in which players feel uncomfortable participating in certain activities, as they could be considered unusual when playing traditional board games. We want to aim to create a context in which the players can feel comfortable playing the game.

Since user tests will be conducted, one ethical consideration is the data collection as well as the storage of the collected data. We will further discuss the ethics regarding the user tests in the methodology chapter 4.

Further issues with designing a game relate to possible handicaps some players may have. While these issues will be considered to some extent, optimizing the design for people with various handicaps is out of scope of this thesis.

2

Background

AR gaming is still at its infancy, even though commercially successful games such as *Pokémon GO* have been released. AR technology is rapidly evolving and there is a lot of new hardware in development. Meanwhile, board games have been around since approximately 3300 BC. This chapter is concerned with the background for this thesis. Because of the mixture of the two major topics, this chapter is quite large. The aim of this chapter is to give the reader an understanding of the terminology, practices, concern, and research that has been done related to both of these topics. Even though not all concepts in this chapter are directly related to our methodology, we aim to bring it up for later discussion, for instance, why we did not take a certain approach in our design and development process.

2.1 Augmented Reality

First of all we need to identify a consensus for what AR is. In its essence, AR is the enhancement of the real world through a lens, adding objects, and distorting the world, where the final rendered result is a mixture of artificial and real world information.

As AR and VR are often mentioned in similar context, it is important to know the distinction. Both technologies are big research topics and are at its surface quite similar. In VR, all of the users perceived information is purely artificial, while AR mixes real world information with virtual information. Another term often used in this context is mixed reality (MR). In 1994, Milgram and Kishino defined the concept of a "virtual continuum" [47] which is illustrated in figure 2.1. This "virtual continuum" describes the states a display can have regarding displaying a mixture of real and virtual environment. The two extremes of this continuum are a purely real and a purely virtual environment respectively. Milgram and Kishino define MR as covering everything on the continuum between these two extremes, which makes AR a subcategory of MR.

2.1.1 Technology

In comparison to VR, the AR hardware is arguably more diverse. As in VR the hardware consists of some headset capable of displaying VR, and is further extended with more gadgets, such as controllers and infrared cameras to make the VR experience more immersive and interactive. As AR is more loosely defined, there are more ways of displaying AR. For this thesis we look at two foundational AR

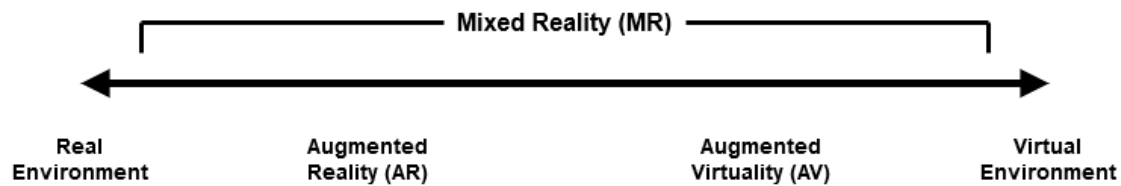


Figure 2.1: The virtuality continuum.

technologies. These are: roomscan AR (RSAR), and image recognition and tracking AR (IRTAR). Other types include for instance face tracking AR, which is used to evaluate expressions. Roomscan AR, which is less common but can be seen as the most state-of-the-art technology.

The most basic hardware equipment is a modern mobile device, a smartphone or a tablet. These devices most often have a camera and microelectromechanical system sensors. This may include an accelerometer, which is used for measuring acceleration of the device, GPS, which is used for real world location tracking, and a gyroscope and a magnetometer, which are used for calculating the orientation of the device. The camera combined with computer vision algorithms can be used for image detection and tracking. This is the hardware this thesis is focused on.

Most mobile devices cannot however, sense depth and therefore a proper scan of a room cannot be done, disabling opportunities for RSAR. There are devices however on the market that enable the user to do this, but this is not a common household technology as other regular smartphones.

Screens for visual augmented reality typically come in one of two variants, optical see-through or video see-through. Optical see-through screens are usually semi-transparent surfaces. Here the user can see the real world scene through the screen, with the digitally augmented content being displayed on the screen, via e.g. projection. Video see-through screens on the other hand use a camera image of the real world scene and display this image combined with the additional virtual content. These screens are typically used in the form of handheld devices, e.g. smart phones, or some sort of head mounted displays.

2.1.2 Mobile Devices

The most common AR capable devices are smartphones and tablets. Most modern day mobile devices have at least one rear-facing camera and multiple other sensors, and are therefore capable of at least IRTAR, out of the types of AR we want to focus on. However, as there is a huge variety of mobile devices from different manufacturers with a wide range of varying hardware components and software, there is also quite a huge difference in what each device is capable of. This is an aspect, that needs to be considered for all development for mobile devices, especially so when developers are dealing with computationally demanding and new technologies. Resulting from this is that developers often having to decide between producing a technically less advanced and potentially inferior product for the sake of making their software available on more devices, or trading-off the amount of potential customers for a



Figure 2.2: The Microsoft HoloLens 2 AR headwear.¹

technically more sophisticated product.

2.1.3 Eyewear

Most augmented reality capable devices, which are not mobile devices, are head-mounted devices. Especially when referencing optical see-through head-mounted devices, they are often referred to as AR glasses or eyewear. In this section we want to look into a few examples of AR eyewear.

Tilt Five Tilt Five is an upcoming kit of devices specifically designed for tabletop gaming [60]. This kit consists of a pair of optical see-through goggles and a wand, which serves as a controller, for each player, and a game board. The game board is not a regular game board, but has markings along its boarder used for tracking.

HoloLens The HoloLens 2 is a head mounted optical see-through display developed by Microsoft [44].² This device is distributed at a relatively high price and mostly advertised towards businesses, not necessarily for entertainment purposes of the common consumer. An image of the the HoloLens can be seen in figure 2.2.

Magic Leap The Magic Leap 1 kit consists of a pair of optical see-through goggles, a controller and a computational unit, which is connected to the goggles with a cable [46]. This device is advertised towards businesses, as well as for use at home as a source of entertainment. Although it is advertised as a product for common

¹Figure source: <https://www.flickr.com/photos/microsoftsweden/16337648861>. Photo taken by Microsoft Sweden and is licenced under the Creative Commons Attribution 2.0 Generic license: <https://creativecommons.org/licenses/by/2.0>

²<https://www.microsoft.com/en-us/hololens/hardware>

consumers, the price tag is several times higher than an average smartphone, which is a cheaper alternative for AR.

2.1.4 Limitations

There are many limitations with current AR hardware and technologies. One issue with optical see-through head mounted displays, is that the users are usually not able to simultaneously focus on the real scene as well as the digital content on the screen [9]. A drawback of video see-through head mounted displays is that it obscures the users eyes, which can diminish social interactions between users [1]. A limitation with most dedicated AR hardware is the affordability factor. As established in section 2.1.3 with the examples of the HoloLens 2 and the Magic Leap 1, they are often several times more expensive than an average smartphone and are thus more catered towards businesses and enthusiasts than the general consumer. While this is not the case with mobile devices, we identified two other significant issues, when using those as handheld augmented reality devices. One concerns the ergonomics of handheld devices, which is further explained in section 2.2. The other relates to the wide range of capabilities found in different mobile devices, as discussed in section 2.1.2. When making use of the latest technology in hard- and software, AR tracking can be very convincing, but with the variety found in mobile devices comes a variety in tracking accuracy, of which not all are at a level we would consider to be convincing.

2.1.5 Augmented Reality Software Development Kits

Software development kit (SDK) is a selection of software development tools. For AR there are four distinct SDK's worth taking a look at: ARKit, ARCore, Vuforia, and Wikitude.

ARKit ARKit is an SDK developed by Apple only available for iOS units that takes advantage of the devices camera, CPU, GPU, and microelectromechanical system sensors.³

ARCore ARCore is a SDK developed by google for android and iOS devices.⁴ ARCore has three main features. First, motion tracking that allows relative tracking in the world. Second, environmental understanding which allows the detection of surfaces. Third, light estimation which allows the estimation of the environments lighting conditions.

Vuforia Vuforia is popular AR SDK for mobile devices, such as smartphones and tablets. It relies on computer vision technology to track images and 3D objects. Compared to ARKit and ARCore, Vuforia is platform agnostic, meaning it will work any platform which meets the requirements in contrast to ARKit and ARCore which only works for iOS and android - respectively.

³<https://developer.apple.com/augmented-reality>

⁴ARCore - <https://developers.google.com/ar>

Wikitude Wikitude is an AR SDK, which supports android, iOS, windows, and a variety of smart glasses. Similar to Vuforia it relies on computer vision technology.

2.1.6 Game Engines

A game engine is a software development environment designed to make games, although a lot of modern game engines are used for other things as well, e.g. architectural visualizations. There are many game engines with direct AR support, where Unity and Unreal Engine are two popular choices. There is always the option to make AR applications without using a game engine, however for this thesis the two engines we would like to take a look at are Unity and Unreal Engine.

Unity Unity⁵ is a very popular choice for indie developers as the engine is easy to learn. Unity has direct support for ARKit, ARCore, Vuforia, and Wikitude.

Unreal Engine Unreal Engine⁶ is generally a popular choice both for small indie or even hobby games, as well as high budget AAA games. Unreal has direct support for ARKit and ARCore.

2.2 Industrial Practices and Challenges Regarding Augmented Reality

The philosophies and practices of companies and professionals within the field of AR are not always backed by scientific studies. There can be several reasons for this, for instance ideological reasons, the results are self evident, or simply due to the lack of resources for doing scientific studies. These, philosophies and practices are however often backed by professional work experience, and through prototyping. Therefore, the references in this sections can not be seen as scientific, but are nonetheless important for understanding the industry, and the challenges they are facing.

Ha did a postmortem talk at Game Developers Conference (GDC) fall 2016, regarding the AR game Woorld [40]. Woorld utilizes RSAR technology using google's Tango. In the talk he identifies several challenges regarding AR development, some solutions, and practices. As the game used Tango, it could not be played on a regular smartphone but rather Tango capable devices. He further explained that people new to AR are not used to having full control of the camera, therefore forcing players to move and get close to object is an important step to increase the experience of the users.

In Hanke's talk from GDC 2019, he identified what he felt were the biggest limitations regarding AR that the industry is facing [41]. As for a consumer the most accessible type of AR equipment is a smartphone, ergonomics is a major factor that developers need to take into account when developing AR applications, as constantly holding the smartphone might be uncomfortable for the user. This is also tied to the social stigma, as it may look like you are using the smartphone to record videos

⁵Unity Real-Time Development Platform - <https://unity.com/>

⁶Unreal Engine - <https://www.unrealengine.com/en-US/>

or take pictures, as this is another functionality the smartphone is associated with. Another aspect that holds true to all handheld applications is battery usage, as if the application drains too much power people will not tend to use the application. Over the different projects and companies, ergonomics is a common factor that they wish to improve. As these companies are not in charge of developing the hardware, what can be done is to design around the fact that holding a phone in front of your eyes can be straining to the users arms.

2.2.1 Augmented Reality Ergonomics

The ergonomics of mobile devices is a major influence when it comes to designing MAR games as stated by Ha [40]. Mobile devices are typically not designed with camera usage for hours in mind. Therefore MAR might not be the most fit way of displaying AR. However, since it is the most consumer available AR capable device on the market, MAR cannot be neglected.

2.2.2 AR Design Guidelines by Google

Google has published their own proposed set of guidelines for designing AR experiences [38]. While they assume the usage of their own AR SDK ARCore, many of the described guidelines can be applied on designing AR experiences in general, regardless of the development environment. Most of the guidelines are relevant to this research as they are often concerned with immersing the user into the experience and furthering their engagement. In the following paragraphs we summarise the considerations and best practices from these guidelines, which we consider to be most relevant to the research conducted for this work.

Environment At the start of the design process the designer should define the size of the experience, e.g. tabletop, room, or world size. The experience which is being designed should also fit the scale, so a board game for instance should take place in tabletop scale. Make the user aware of the needed space upfront to avoid interrupting and potentially breaking the experience later on. Consider the possible places in which the experience may take place and show the user the ideal conditions for the experience, so they can potentially adjust to the environment to match those. The users expectations should be set right away, if you want to surprise them let them know where the surprise may take place. Design the experience for responsiveness, a tabletop experience should be scalable to fit tables of different sizes.

User If the experience demands exploration, remind the user that they can move, as first time AR users may forget that they can, and encourage movement by giving goals only achievable by moving. Let the user know which movements will trigger the experience and guide them through the types and range of possible moves. Movement can be a tool of engagement in AR, but the users should be eased into the experience and be able to feel comfortable at all times. Therefore the experience should not require movement unless it is necessary, and should not require physically

demanding or sudden movement. Users may have various reasons to not be able to move around, so the experience should provide alternatives, e.g. rotating virtual objects, and have instructions be visible from all angles. Most important is to always keep the users' safe. Consider where the users attention is directed and remind them to keep awareness of their surrounding. Never encourage the user to walk backwards. Avoid long play sessions to prevent fatigue. Allow users to change the way they are holding their device, to take breaks from AR usage, e.g. by including resting points in the experience flow, and to pause the experience to pick it up later.

Content The virtual content can be 3D or 2D. For an immersive experience the virtual elements should aim to blend in with the physical environment, by e.g. estimating the real world lighting, using shadows, occlusion reflections and collisions. This along with moving objects can also help to create a sense for depth and distance. Build confidence and reduce frustration. Give hints on how to detect the tracking target and transition smoothly between detecting and tracking. Inform the user about changes in the system status immediately, e.g. when tracking target was found. Designers should consider three regions, downstage (close to the user) for close examination of objects, upstage (far from the user) to encourage movement and exploration, and center stage (comfortable viewing range) for interacting with objects. Consider the size of touch targets for user interactions and guide user with visual cues regarding selecting, translating, rotating and scaling objects.

Interaction Have clear transitions from 2D screens to AR and let the user initiate the transition. Do not use vibrations, they can result in the AR tracking being lost. Use low-frequency sounds to emulate vibrations. Audio usage can encourage engagement and exploration, but apply it mindfully not to distract the user from the experience. The camera being inside virtual objects can break the immersion. Make the insides of objects blurry to indicate to the user that they are not supposed to be there. Multiuser experiences may require more hand-holding. Guide the users through each step to make connecting the devices as seamless as possible. Create immersive world and easy to use interface. Ease the user into the experience, then get out of the way. Avoid automatic pop-ups and 2D interfaces, as they distract and disrupt the immersion. If on screen controls are necessary, make them usable without thinking, e.g. make them large and without text label. Let AR be launched quickly and make the tutorial part of the flow. Do not inform the user about everything at once. Use visual cues and animations instead of written instructions, and take advantage of established interaction models, which the user already knows. Provide support for landscape as well as portrait mode for more comfort and immersion. Consider button placements and the effects of the varying camera positions. When encountering errors, help the user to recover and get back to the experience by guiding them along a clear path. Inform the user about what went wrong without blaming them. Allow the user to easily and quickly reset the experience.

2.3 Pervasive Games

Before describing AR games, we need to take a look at pervasive games in general, as most AR games can be categorized as pervasive games. Pervasive games, are games which are extended to the real world. There are several definitions regarding what a pervasive game is, originally it had to do with live action role-playing games with extended computing technology to bridge the physical and digital worlds. Arguably the most popular pervasive game ever made is *Pokémon GO* [51].

2.4 Augmented Reality Games

Augmented reality has been implemented in multiple games, whether as a core functionality or a side feature. In this section we will look at a couple of games, that use AR to some extent. As research does not provide scientific data on all of these games, we will also look into game reviews from professional video game and technology journals. We are aware that the information gathered from these sources is not scientific and can be heavily subjective. However, we think that relevant information to formulate design considerations can still be drawn from these sources.

2.4.1 Pokémon GO

While the location based gameplay of Pokémon GO is often treated as AR, this thesis is only concerned with the types of visual AR discussed in section 2.1. However, visual AR is also integrated in two features of Pokémon GO, when catching Pokémon and in a snapshot mode. While the catching mechanic is integral to the gameplay in Pokémon GO, the AR feature of this mechanic is optional. Some players may perceive the experience as being more immersive when using the AR feature for catching Pokémon, but it can be considered to be just a gimmick as it does not impact the core of the gameplay. The AR snapshot mode on the other hand, while not necessarily integral to the player advancing in the game, enables the players to create content and encourages them to share it on social media. While technologically different, the AR in this case is used for a similar purpose as the photo filters briefly touched upon in chapter 1. This social aspect of being able to share a part of your experience with people all over the world may not be an integral to the gameplay itself, but it can be an important factor for some players to stay engaged, as it enables them to set and pursue intrinsically motivated goals, as well as fulfill social needs.

2.4.2 EyePet

EyePet is a pet simulation game which was released for the PlayStation 3 in October 2009 and used the PlayStation Eye camera to display an image of the player inside their room with an augmented virtual pet. According to a review by IGN the author felt more immersed and attached to the pet compared to other pet simulations that do not make use of augmented reality [59]. The virtual pet reacting to most motion gestures without the use of any special controllers was described by another review

as being an engaging experience and made the author connect to the virtual pet on a personal level. On the other hand it was noted, that physically interacting with something that was visible on the screen, but not in the real environment, felt strange in the beginning and the author would have wished for more guidance and reference points from the game [52]. Another point of critique was that, while the novelty of the experience was exciting at first, this effect wore off rather quickly, as the pet did not seem to evolve. From this the conclusion could be drawn, that when a player is made to believe that something is taking place in a real environment, they expect the elements to also behave realistically, e.g. that a pet learns and grows over time. Another conclusion to this could be that a novel experience can be exciting and draw players in, but that the gameplay needs to provide enough other content and variety to keep them engaged and wanting to come back.

2.4.3 Minecraft Earth

Minecraft Earth is a MAR game which released in early access in October 2019. One part focuses on location based gameplay, similar to Pokémon GO. The other part which features visual AR, unlike Pokémon GO, can't be played without AR. Here virtual blocks will be placed and anchored on a real surface. The players can then mine these blocks to gather resources or build upon these blocks. According to AppleInsider the tracking is highly dependant on the lighting and the texture of the surface, but can produce convincing results [50]. Minecraft Earth also allows the player to view the AR content in different scales, so that virtual building will either appear like it is made from LEGO or the size of an actual building. According to Digital Trends this allows the players to switch between easy editing and an impressive experience of viewing their creations in full-scale [58].

2.5 Board Games

To understand concepts with regards specifically to board games, we first need to have an understanding of tabletop games, since board games is a subcategory of tabletop games. Tabletop games, are games that are played on a flat surfaces, often a table, hence the name tabletop games.

A board game can be defined by having at least one moving piece and a game board where it can move, according to some rules. Board games comes in a huge range of varieties, from Chess to Gloomhaven.

2.5.1 Limitations

There are many limitations with board game design over digital game design. For instance, the rules usually have to be a bit simpler for board games, as there is no computer to keep track of the game state, perform calculations, and enforce rules. Another limitation is the feedback a board game can give to players regarding the current game state and the effects of their actions, while a digital game can be very rich in it's audiovisual feedback.

2.5.2 Opportunities

One thing board games are better at than digital games, is giving the players the power to adjust the rules to their needs or wants, which is often referred to as playing with house rules. While it is possible to modify digital games, it is often more complicated and restricted. Some digital games take into account that not every player wants to play the same way, however, in these cases modifications are limited to the options provided by the game. With board games, there is no digital system which enforces any rules, so the players are pretty free to change the game to their liking in any way.

2.6 Augmented Reality Board Games

While AR board games are relatively new and not very well established, games like this have been developed before. In this section we want to look at existing AR board games.

2.6.1 BattleBoard 3D

Researches from Aarhus University in Denmark developed a prototype of an AR board game in 2004 with the aim of creating an experience that provided more social interaction than video games and more variation than traditional board games [1]. The prototype was based on ARToolKit and used markers made of LEGO bricks as tracking targets. While major technological advancements have happened since then, there are still some conclusions on designing AR board games that can be drawn from this research. They mostly tested the prototype with children and two different setups for displaying the digital augmentation, with a pair of video see-through goggles and with a screen. They noted that the social interaction was more intense with the screen setup, as the goggles obscured the players' eyes, reducing the sense for the other players presence. A disadvantage of the screen, was that the attention of the players kept switching between the screen and the physical scene. This effect could potentially be lessened with mobile devices, as they would function as a video see-through screen, but should still be considered when designing MAR content as players may feel the need to switch between holding the device and viewing the game board without the augmented content. On the other hand playing with the goggles enhanced the illusion of perceiving the digital pawns as live pieces. This effect can potentially be contained to some extent with using mobile devices as video see-through screens. Using mobile devices could possibly combine the advantages of the two setups to some extent, although optical see-through goggles would probably be even more suited to do so. Another issue that was brought up during the tests, is that the players would have liked to see more visual variations, e.g. regarding animations of the digital figures, more complex rules, and other additional features, such as high score systems, which are all aspects more common in digital games than in traditional board games. Furthermore it was stated that, while the physicality of board games adds to the experience, some physical actions can also be perceived as disrupting the game flow, if they take up too much

time. The overall conclusion was that the children seemed to have experienced the combination of social interaction found in board games and the dynamics of video games as exciting and amusing.

2.6.2 AR Monopoly

In 2010 Eray Molla and Vincent Lepetit worked on augmenting the well-known board game Monopoly, as an example of using physical game elements, such as the game board and the player pawns, to add digital visuals through the use of a webcam and Computer Vision techniques [48]. While their digital implementation was limited to adding visual elements, leaving all of the game logic to be handled by the players they claim that this addition already made the traditional board game more immersive. While the technical implementation of this work is well documented, no actual data on player immersion is presented, which is why this statement should be viewed with skepticism.

2.6.3 AR Tabletop Role-playing Game

Oğuz Turan Buruk et al. did research on augmenting tabletop role-playing games with custom wearables in 2017 [8]. While their research focused mostly on the design of the custom hardware to enhance the experience of tabletop role-playing, they emphasised the importance of physical elements, like dice, and materiality in general for all sorts of tabletop games, including board games.

2.6.4 Tisch

In 2012, Ulf Hartelius, Johan Fröhlander and Staffan Björk from the Department of Applied IT at the University of Gothenburg developed an application for the Microsoft Surface to digitally support board- and role-playing games [42]. Tisch was developed to be a generic and modular system, that is meant to support a variety of games. Explicit goals in the development were to allow House Rules, allow improvisation and preparation, reduce or remove Excise from the supported game, provide immersive features to enhance the gaming activity while being Calm Technology, and having Social Adaptability and keeping Social Weight low as to avoid the system interfering with the social interactions between players. While Tisch was developed to serve as a supportive tool for existing tabletop games, and this research is concerned with the development of board games dedicated AR systems integrated into the game, many aspects of what make a successful blend between board and digital game in general were explored in the development of Tisch.

One aspect is that a lot of value of playing board games comes from social interactions. Therefore a digital system which degrades the social interactions between players can be unsuitable for use with a board game. A digital system used with a board game should be able to handle different amounts of attention from the users. The importance of being able to follow house rules when playing board games is stressed at multiple points in the work. A digital system should therefore be able to be used to varying degrees and not always dictate all the rules.

Another aspects of playing board games pointed out by Hartelius et al. is that player's actions are not always purely rational. This means that actions, like e.g. die rolls, which could easily be translated into a digital system, might be desired in a physical space, as the simple act of rolling the die themselves gives the players the illusion of having more influence over the outcome, which can add to the thrill of the game.

The goal of reducing excise was stated to be challenging, as what is perceived as excise by one player can be fun to another. One of the user tests showed players choosing to carry out tasks physically rather than using the corresponding digital functions. It was also stated, that Tisch also introduced new excise, as players had to additionally interact with the digital system on top of the tabletop game. However, this newly introduced excise was not pointed out by any of the players, so it might be negligible if the value created through the system is perceived as greater than the excise.

The research around Tisch showed, that immersive features provided by a digital system, like background imagery, music, or visual effects, can add to the game experience in a way that is hard if not impossible to recreate with a purely physical game. If the digital system is designed to create a more immersive atmosphere, Hartelius et al. recommend to keep in mind, that if the system requires too much attention this may destroy the mood, which it tries to create.

The overall flexibility of the Tisch system was perceived as positive and for instance allowed bored users to entertain themselves with the system, while not being in agency. However, it was also noted that many players did not take full advantage of the functions provided by the system, as making configurations was perceived as being complex and obscured the game area.

Concluding the researchers stated, that many games would have benefited more from an individualized system as opposed to the generic system that is Tisch, which is an advantage we would have, as we seek to develop a game with a dedicated AR component. Furthermore it was stated, that the goals, that were set for the development of Tisch generally had merit and are therefore something we should also take into consideration.

2.6.5 Computer-Augmented Games

The researchers Karl Bergström and Staffan Björk made a case for Computer-Augmented Games (CAGs) in 2013 [4]. To explore the design space of CAGs they establish a framework using a multi-dimensional typology. The identified dimensions are the following:

- "Player agreed" vs. "Artefact-encased" game logic
- "Limited" vs. "Rich" audiovisual content
- "Fluid" vs "Fixed" game content
- "Manual" vs. "Automatized" excise
- "Low-effort" vs. "High-effort" modification of rules
- "Low-effort" vs. "High-effort" modification of game state
- "Unlimited" vs. "Constrained" action space
- "Low" vs. "High" Tangibility

While most of the CAGs which were analysed in their research mostly tried to reduce excise or provide additional capabilities without drastically increasing the excise for the players, Bergström and Björk state, that CAGs could push towards the endpoints of the scales and be potentially located anywhere on them. However, it is also pointed out that CAGs aiming to automate excise generally have it more difficult to provide fluid game content and modifiable rules. Similarly rich audiovisual content seems to increase the difficulties of adding new content. Being aware of these design dimensions and keeping the mentioned conflicts and possibilities in mind, may help us to define our game design considerations.

2. Background

3

Theory

There are a few general definitions, with regards to game design that must be established. Such as patterns and mechanics. Also analytical frameworks used for game design, primary the MDA model. In this section we go over these definition and the theory in regards to this thesis.

3.1 Gameplay Design Theory

In this section we look at gameplay design theory, and methods for analysis. For instance *gameplay design patterns* and *game mechanics*.

For this thesis we use the definition of gameplay design patterns provided by Björk [5]. The gameplay design patterns we will use in this thesis are taken from gameplaydesignpatterns.org. Gameplay design patters are generic patterns used in game design for easier expressions of purpose and analyses. A gameplay design pattern is defined by a name, a description, the consequences of its usage, how it is used, and its relations to other patterns.

For game mechanics in this thesis Sicart's definition is used [57]. In which a game mechanic is an action that can be executed by an agent, for instance a player. A mechanic can for example be a spell that can be cast using the "A"-button on a controller in a role-playing game.

3.1.1 MDA Model

The mechanics-dynamics-aesthetics (MDA) framework is a framework for the analysis of games [45]. Using this framework, games are broken down into three components: *mechanics*, *dynamics*, and *aesthetics*.

Mechanics Not to be confused with Sicart's definition of game mechanics. The mechanics components defines the base structure of the game - the rules of the game and every action a player can take.

Dynamics Dynamics act as the run-time behavior, based on the mechanics, acting on player input and cooperating with other mechanics. For instance this could be players teaming up against another player in a competitive context.

Aesthetics In the context of the MDA framework, aesthetics refers to the emotional responses from a player. These may include but are not limited to:

1. Sensation: Game as sense-pleasure.
2. Fantasy: Game as make-believe.
3. Narrative: Game as drama.
4. Challenge: Game as obstacle course.
5. Fellowship: Game as social framework.
6. Discovery: Game as uncharted territory.
7. Expression: Game as self-discovery.
8. Submission: Game as pastime.

3.2 Player Engagement

As we aspire to establish a framework on how to design a game experience to be engaging, we have to first find a consensus what player engagement is and which factors in a game can result in engagement. What it means for a player to be engaged can be unclear, and the topic has been approached from various angles and has been defined in several different ways, therefore there are also multiple theories on how player engagement is achieved. Concluding we will explain the definition of player engagement used for the execution of this thesis.

3.2.1 Measure of Involvement

The researches of "The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing" use engagement as a generic term for game involvement [6]. The terms of immersion, presence, flow, psychological absorption, and dissociation are used to represent a progression of engagement.

Immersion describes a state of becoming engaged in play while preserving awareness of one's surrounding. Presence describes the experience of perceiving oneself to be inside a virtual environment. Flow expresses an altered state, in which a person feels to be in control, to be one with their activity and experiences time distortions. Psychological absorption represents an altered state of consciousness, in which thoughts, feelings, and experience are separated and affect is not as accessible to the consciousness. One important difference between flow and psychological consumption is stated to be that the experienced affect in flow is by definition positive, while psychological consumption can be accompanied by negative affects, such as anxiety or frustration. The term dissociation describes "non-pathological dissociation" in this context and is used to describe everyday experiences of psychological absorption, e.g. "highway hypnosis".

Furthermore it is stated that the level of engagement a player experiences is not only dependant on the game they play, but also on the individual's potential to become engaged. The research seems to suggest that most players are capable of engaging to a state of immersion or even presence, while considerably fewer people seem to be able to engage to an altered state of mind. According to this article becoming deeply engaged in play seems to be an important part of the experience of playing video games, regardless of the factor, if the induced affect is perceived as being positive.

3.2.2 Continuation Desire

In 2011 Henrik Schoenau-Fog suggested to think of player engagement as a continuation desire and distinguished it from player motivation, which the author described as the reason for people to start playing [43]. As a result of the research, Schoenau-Fog proposed a framework which tries to explain how to sustain player engagement.

This framework describes the relation between four previously identified components, which are *Objectives*, *Activities*, *Accomplishment*, and *Affect*, and further, how they support continuation desire. According to Schoenau-Fog's study, all of these components contribute to the player's desire to continue playing. In the pursuit of an objective the player engages in activities, which lead to accomplishment and an experienced affect. If this experienced affect is a positive one, the player is more likely to want to continue and take on a new objective.

Each of these components consists of conceptual categories, in which triggers of engagement as well as disengagement can be found, e.g. a category of activities is exploration, which can engage the player by letting them discover novel elements or encounter the unexpected and disengage them when the player gets stuck or it takes them too long to reach a desired location. The findings of Schoenau-Fog's study furthermore suggest, that other concepts often used in relation to engagement, such as immersion, presence, and enjoyment, are related to the affect component of the proposed framework, which implies that player engagement is a prerequisite for these concepts to be experienced.

3.2.3 Game Flow

Flow is a concept often associated with player engagement. In the book "The Art of Game Design: A Book of Lenses", Jesse Schell describes flow as a "state of sustained focus, pleasure, and enjoyment" [55, p. 138]. Some key components for putting a player into a state of flow are stated to be *clear goals*, *no distractions*, *direct feedback*, and *continuous challenge*. These components should keep the player within the margin between boredom and frustration. Schell bases these statements on Mihály Csíkszentmihályi's research on flow [12].

Schell presents two ways of approaching this act of balance between a player's skill and the provided challenge. One of them is linearly increasing the challenge as the player's skill improves as illustrated in figure 3.1. The other proposes a cycle of tension and release as illustrated in figure 3.2. Here the player is suggested to receive a reward after overcoming a challenge, which temporarily decreases the challenge, before the challenge increases again. Schell argues that the second approach is probably the more interesting experience, as the oscillation between excitement and relaxation would lead the player to experience pleasure. According to Schell designers should consider if the game provides clear goals, if parts of the game distract the player to a degree that they forget about their goal, and if the level of challenge is appropriate throughout the experience.

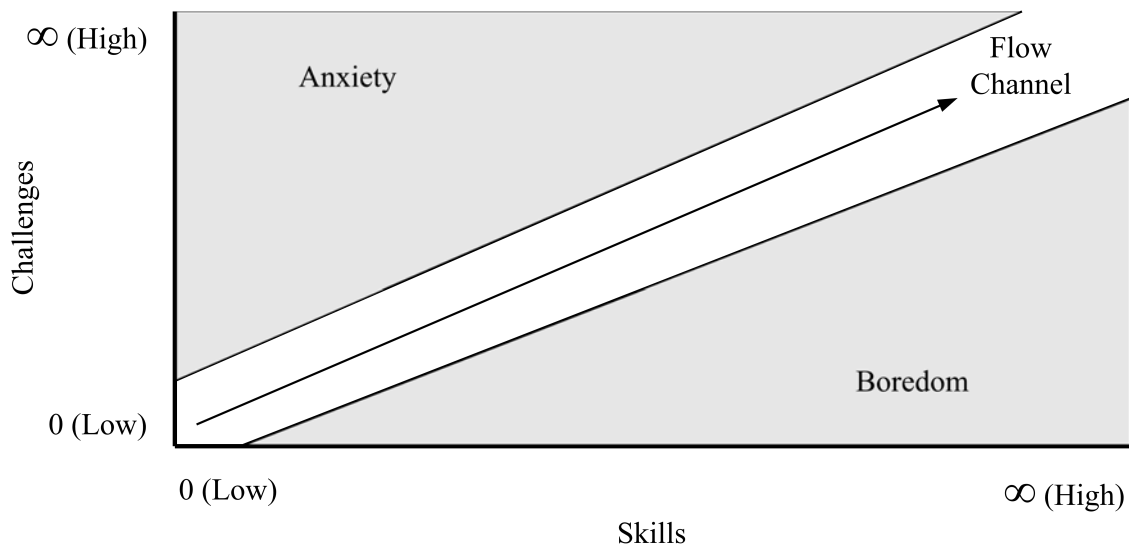


Figure 3.1: Increasing the challenge proportionally to the player’s skill

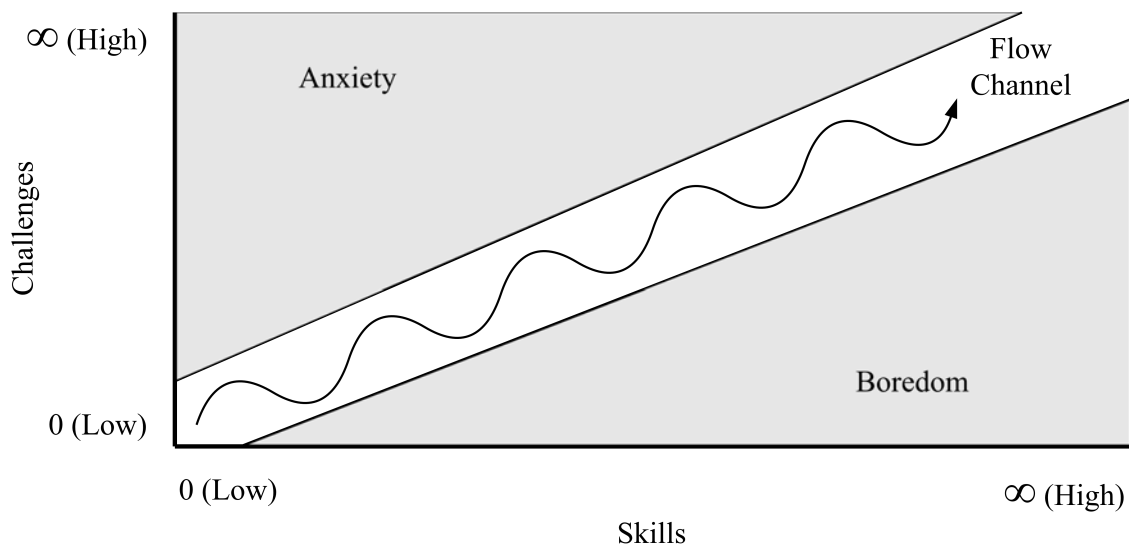


Figure 3.2: Cycle of increase and release of challenge

3.2.4 Human Motivation

As player engagement is related to what makes people play and more specifically what makes them want to keep playing, it should be possible to draw relevant information from looking at why people play and player motivation on a more general note. Here Schell connects psychological research on human motivation and needs to gaming [55]. While many games help players to fulfill their need for self-esteem through mastery and achievement, especially multiplayer games are also good at covering more basic needs, specifically social needs, by letting the player connect to other people. Further it is stated that games are generally good at fulfilling the three mental needs of Competence, Autonomy, and Relatedness, by providing mastery of the game, freedom of play, and playing with other players.

Additionally Schell asserts that hardly any player is exclusively intrinsically or extrinsically motivated, but most times it is a mixture of both. From this the conclusion that a game should provide external goals for the player to strive for as well as space for the player to set their own personal goals, can be drawn. These motivators can be one of two kinds, either pain-avoidance or reward-seeking. A game can provide both kinds of motivations, but when designing these, one has to be aware, that while they sometimes combine well, they can also end up contradicting one another. Another factor, which can motivate people is stated to be novelty, as people like to explore new things. This aspect can be especially relevant for us, as we are looking into a relatively novel genre, which many players did not have contact with yet. Things to consider for a game designer regarding novelty are, how quickly the novelty of the game wears off and if a good mix of novel and familiar game elements are provided.

3.2.5 Social Play

When considering human motivation as an aspect of player engagement sharing an experience is a large factor. Especially in the context of board games the social aspect of play is arguably a very important aspect.

Historically games have been a social experience, with some exceptions like the card game Solitaire (also known as Patience). However due to the rise of computers in the last few decades, one cannot claim that games can only be played in a social context anymore. This is not to say that all computer games are non-social, on the contrary, multiplayer computer games are immensely popular, especially during the two last decades due to the increased access to broadband. However, people who play computer games today have a choice between playing social multiplayer games or solitary single-player games. Meanwhile, the choice is more narrow for board games, as most of them are targeted towards multiplayer. There are of course exceptions, for instance the popular board game Gloomhaven, a cooperative game, gives the player the choice between playing solo or with other players. What is interesting about the game Gloomhaven is that there is really no need to play the game with other players, as the game is played against a primitive game artificial intelligence, one player could control all of the allied characters and maybe even make better choices than if you would play the game as a team. However, in the game rules of Gloomhaven, there is encouragement that players talk about tactics in a general way, for instance do not use numbers. This changes the game Gloomhaven quite a lot, and makes the experience of playing the game quite different when playing alone or with other players. These sort of rules would be hard to recreate in a multiplayer computer game due to the conception players' are expected to have, for instance *match making*.

The focus of social play is the relationship between multiple players and the game [54]. Social play can be divided into two categories: *external* and *internal*. External social play is the social play of real world roles that are transferred into the gameplay. While, internal social is the interactions directly derived from the gameplay.

3.2.6 Chores

Yan Xu et al. reported findings regarding social play from a video analysis of people playing board games [63]. From the video the authors extracted, transcribed, and categorized event from the sessions by using the method “Interaction Ritual”, a method adapted from micro-sociology. From the analysis five categories emerged: *chores*, *reflection on gameplay*, *strategies*, *out-of-game*, and *game itself*. Chores is the finding of their research that stands out as the other findings have already been discovered and discussed in other research. In the case of board game, a chore is something that the players need to do, without any strategic thinking, nor any luck based elements e.g. a roll of dice. For instance a chore can be shuffling a deck of cards, reading rules, or calculating the the number of hit points enemies have left, as in the case of Gloomhaven.

Chores are typically something that is missing from computer games. When creating the AR board game, removing the chores from the game would be an easy task, and might seem like an evident thing to do. However, in the finding of Xu et al. these chores bring a rich social interactions. As these chores showed an enhanced level of physical presence and increased awareness of the game.

3.2.7 Definition of Player Engagement

Based on aspects of the previously presented definitions of player engagement we formulated a definition for the use throughout this thesis. For the purposes of this thesis we would define player engagement as players actively participating in the process of the game through actions and decision making, being motivated to play, as well as being invested in the outcome of the play session they participate in. Ultimately, we define player engagement as the following:

A player is engaged when actively participating in an activity, while having an emotional connection to the outcome.

4

Methodology

This chapter is concerned with the methodology of our thesis. As the final conclusions, we want to provide a set of considerations for how to design a MAR board game. In this chapter we also discuss our approach for retrieving these conclusions.

4.1 General Approach

The general approach for this thesis can be described in a few steps. A diagram of the approach can be seen in figure 4.1.

First of all, we studied various literature as well as industrial practices concerning the research topic.¹ The findings are documented in the chapters 2 and 3. Based on these findings we will start the execution with the first iteration of designing the MAR board game.

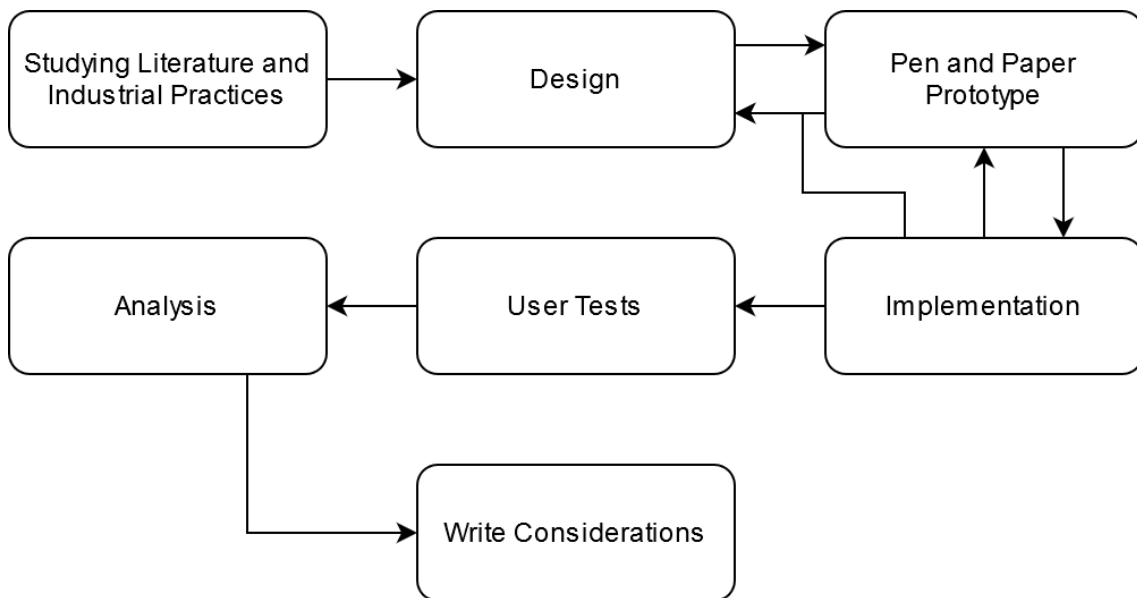


Figure 4.1: Diagram of the approach.

¹Initially we considered formulating considerations based on the findings of the literature study. However, we decided against doing so as the result of this research are also considerations and we wanted to avoid confusing readers.

4.2 Board Game Development

For the board game development we plan to apply experimental gameplay design [62]. In a broader sense this means, that we will develop varying design, and conduct some sort of studies with it. In our case this means, we will iteratively design a MAR board game and conduct a user test with a resulting prototype, to draw conclusions and answer the posed research question. As the research of trying to find and develop considerations conducted by us can be argued to be more open than answering just one concrete question, we think an open design experiment is more suitable than a classical controlled experiment. As the genre of cooperative MAR board games is relatively new and unexplored, we aim to design considerations with regards to multiple factors, therefore we see an explorative design experiment to be fitting. The development of the game will be extensively documented, in form of a written development diary, and pictures and videos of the game in different stages. To be able to conduct user tests which will result in valuable data, it is necessary for the resulting gameplay design and prototype of this work to be understandable and playable.

4.2.1 Design Thinking

Design Thinking is a solution-based methodology to solving complex problems which deal with unknowns. As established in section 1.2 we deal with such a problem, as the design problem this thesis is concerned with is a wicked problem. In this section we want to establish the five stages of Design Thinking, proposed by Hasso-Plattner Institute of Design at Stanford, as an approach to the design of the prototype developed for this thesis. The Interaction Design Foundation describes these five stages of Design Thinking as follows [13]:

Empathize As Design Thinking is a human-centered design process, the first stage is about gaining an understanding of the problem and the human-needs involved. In this stage designers should try to gather as much information as possible, given the time constraints and other circumstances. This information gathering can be done through various means, e.g. consulting experts, understanding experiences by engaging with people or immersing oneself into the environment to gain a personal understanding.

Define The second stage is concerned with defining the identified problems based on the information gathered and created in the previous stage. Here the problem should be defined as a human-centred problem statement, rather than a formulation of the designer's wish. Defining the problem in that way should help the designers searching for solutions and gathering ideas. This results in the design process progressing to the third stage.

Ideate When starting this stage the designer should have an understanding of their users and the problem. During the ideation stage the designer should identify new solutions to the problem statement formulated in the second stage and view

the problem from alternative angles. This can be done through various ideation techniques, e.g. Brainstorming or Brainwriting. Early in this process the designer is encouraged to develop solution ideas in high quantity and to later use other techniques to test the ideas.

Prototype In this stage the designer is supposed to produce inexpensive and scaled-down versions of the product, which implement the solutions generated during ideation. These prototypes are then tested with small groups of people from within or outside the development group. With the aim to identify the best solutions to the identified problems, the solutions are then accepted, rejected, or improved and re-examined. When finishing off this stage, the designer should have a better understanding of the constraints of the product, the present problems, and how users interact with the product.

Test During the test stage a complete version of the product which implements the best solutions identified in the prototyping stage is being tested by the designer or evaluators. While this stage is the last of the five stages, it does not mean that the design process ends after this stage is completed. The results of the test stage are often used to redefine the problems or reiterate on the solutions with a better understanding of the users and their behaviour.

4.2.2 Iterative Design

According to the Interaction Design Foundation, the five stages of design thinking discussed in the previous section 4.2.1 do not have to be executed in sequence. It is emphasized that they do not have to be executed in a specific order and can sometimes even occur in parallel. The described stages are to be understood as modes not as steps. Therefore the stages can be repeated iteratively, as seen fit to each individual project. This is an instance of design as an iterative process.

Helen Sharp et al. also refer to iterative design and present the four basic activities of interaction design, discovering requirements, designing alternatives, prototype, and evaluation, in a process model which suggests to execute those activities iteratively. They also mention iterative design to be a generally accepted principle for a user-centered approach in interaction design when referring to the three principles of design established by John D. Gould and Clayton Lewis in 1985. [56]

Gould and Lewis suggest the principle of iterative design as when problems are identified in user test they must be fixed which results in design being an iterative process. They describe iterative design as a cycle of design, test and measure, and redesign. This cycle is to be repeated as often necessary. [39]

4.3 Evaluation

The last step of this research is going to be evaluating the prototype and formulating considerations based on that evaluation. There are multiple types of evaluations. Out of the types identified by Helen Sharp et al. an evaluation in controlled settings

directly involving users seems to be appropriate considering the constraints of this research. We plan to conduct the evaluation by gathering user data and analysing it. To perform a successful data gathering it is important to consider five key issues, setting the goals, identifying the participants, the relation to the participants, triangulation, and conduction of a pilot study [56].

4.3.1 Qualitative vs. Quantitative Data

There are two types of user data which can be gathered for evaluation, qualitative or quantitative data. According to Alan Cooper et al. these two types of data come with different pros and cons, and are more or less suitable depending on the context and purpose of the gathered data. Quantitative data has various uses in design research. Quantitative data can be used to group potential customers by demographic criteria and classification systems may help to predict the purchase powers and motivations to buy the product of potential customers among other factors. This may allow a business to evaluate the potential return on investment and assess a product's viability. Other uses are also identifying user behaviours, design problems that need solving and interview targets. While quantitative data is often considered to deliver supposedly more objective results, these results are often still subject to interpretation which is especially true when describing human activities. Cooper et al. also claim that human behaviour is too complex to solely rely on quantitative data to understand it. Qualitative data on the other hand is often more suitable to identify how and why users behave a certain way. This can often be done in rich detail which is necessary to reflect complex real human situations. Qualitative data should help to design product that better serve the needs of potential users. Further qualitative data enables designers to identify patterns of user behaviours more quickly, understand the domain of the product and vocabulary and social aspects connect to that domain, as well as reveal how existing products are used. This may also help to progress the design project, as it may for instance give credibility to the design team as design decisions are more easily traceable to research results. According to Cooper et al. qualitative data is also more likely to reveal relevant answers to important questions more quickly and with fewer expenses [10].

4.3.2 User Testing

Usability Testing is a common approach for collecting user data in a controlled environment and makes use of a combination of methods, e.g. experiments, observations, and interviews. The goal is often investigating if a typical user from the target group can perform the tasks the product was designed for [56].

While throughout the development iterations calculations, simulations, and internal test will be conducted to trim down, and improve the gameplay design, the concluding test to provide research results will be conducted with players, invited for the sole purpose of the user test. Conducting a user test with players and creating the right context for the play sessions is integral to our research, as games can be considered second order design [54], which means that the player experience is not defined by the game itself, but through the game session in which the player

participates.

For the user test we will have groups of players play the prototype of the MAR board game. Conducting the user test in a controlled environment enables us to influence environmental and social conditions. This way it is possible to create a setting which is known and can be taken into consideration when interpreting the gathered data. During and after the play session we will use a combination of observations and one-on-one interviews, as recommended by Cooper et al. to effectively and efficiently gather qualitative data [10].

Interviews We plan to conduct the one-on-one interviews in a semi-structured way and use closed as well as open-ended questions. With this approach we hope to get relevant answers to the research question, but also be able to potentially explore aspects of the topic, which we have not considered. The interview will be led with pre-planned questions, which should then lead to a discussion. The questions will be formulated to not suggest an expected answer. For conducting the interviews we plan to prepare an interview guide, to assure that the same topics are covered and introductions contain the same information for every interviewee [56]. Amanda Cote and Julia G. Raz propose an interview guide to cover an introductory script, warm-up questions, substantive questions, and demographic questions [11]. Further they suggest to test the interview questions with people familiar with the project, before conducting the actual interviews.

Observations As we will observe the users in a controlled environment there are certain things that have to be kept in mind. The observation will most likely be perceived as more formal than in the field, and participants may be more apprehensive. If the observation is conducted with multiple groups it is recommended to use a script to ensure that every participant receives the same treatment and information. Furthermore, the arrangement and orientation of recording equipment demands extra attention to take advantage of the controlled environment, as it allows a more elaborate setup than in the field which allows to focus on details [56].

Ethics The first ethical consideration to be made before the user test is that our design has to be evaluated before these tests are appropriate for the intended user group. We will inform every participant about the ramifications and possible consequences of the user test and ask for their consent. Only under the condition, that the participant gives us an informed consent, will they be able to partake in the user test. As we plan to record data in multiple ways during the play session as well as the interviews following these sessions, there are considerations to be made regarding data quantity and the sensitivity of the information, as well as the storage and access to said recordings. One step towards using data ethically is avoiding to collect as much data as possible in case it might be useful for subsequent analysis, but only recording the data which contains information relevant to the previously defined goals of the data gathering [56]. If this is done thoroughly, this can help to reduce the amount of recordings of sensitive information, and therefore reducing the risk of potentially harming the participants. If a participant is referenced individually in the publication, names and other personal information will be changed so the

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shared material can not be linked back to the individual. Only the authors and their supervisor will be able to access any of the recordings. The recordings will be destroyed before the publication of the thesis. During the interviews only notes will be taken. All handling of the gathered data should happen following the principles of fairness, accountability, transparency, and explainability [56].

5

Planning

To begin this chapter we would like to quote the Supreme Allied Commander Europe as well as the 34th President of the United States of America, Dwight D. Eisenhower: "Plans Are Worthless, But Planning Is Everything" [15]. Dwight D. Eisenhower, famous for many things, among them the planning and supervision of the invasion of Normandy during the second world war. So even though we try to plan everything out, it is unlikely that everything will go according to plan. This is the philosophy we use in regards to our planning.

5.1 Overall Planning

Our initially proposed time plan seen in table 5.1 has been adjusted. Now the overall planning has been split into four periods. Week 1 to week 5, week 6 to week 10, week 11 to week 15, and week 16 to week 20. As of writing this, we are currently at the end week 4.

Week 01-02	Research, learning software, writing planning report
Week 03	Formulate requirements
Week 03-12	Project work (iterating between design and implementation), writing intermediate reports
Week 13	User tests, writing intermediate reports
Week 14-20	Writing thesis report, preparing oral presentation and opposition
Week 20-22	Finalising thesis report

Table 5.1: Initially proposed time plan

5.1.1 Planning: Week 1 to Week 5

The planning for week 1 to week 5 is seen in figure 5.1. As the first four weeks have already passed, the planning for this first period is done partly in hindsight. In the beginning of this week we were looking at software learning to get an understanding of the scope of this project. After that we were looking into the methodology to understand what exactly we were going to do with this thesis. During week 2 to week 4 we have spent time writing and doing research. As of next week, week 5, we will begin with the execution of the project work.

5. Planning

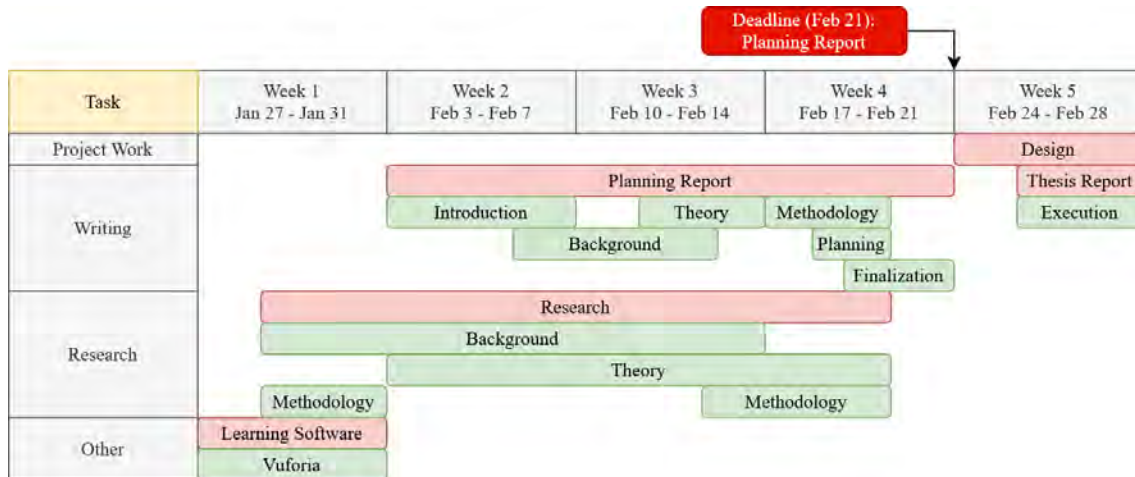


Figure 5.1: Planning for week 1 to week 5.

5.1.2 Planning: Week 6 to Week 10

The planning for week 6 to week 10 is seen in figure 5.2. This period is focused on project work, as we will design and implement our prototype. Meanwhile, we will continuously write on the "execution" chapter of our thesis.

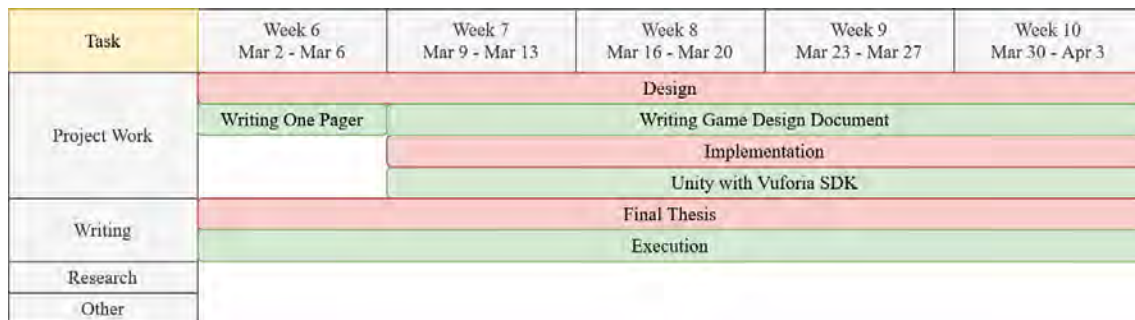


Figure 5.2: Planning for week 6 to week 10.

5.1.3 Planning: Week 11 to Week 15

The planning for week 11 to week 15 is seen in figure 5.3. In the beginning of this period we will invite people for user tests, meanwhile we will finish up our game by gold plating and fixing potential bugs. After that we will conduct the user tests as well as writing the "results" chapter of our thesis. Further the majority of this period is focused on writing the "discussion" chapter, and finally the "conclusion" of the thesis.

5.1.4 Planning: Week 16 to Week 20

The planning for week 16 to week 20 is seen in figure 5.4. The period, week 16 to week 20 begins with a buffer week, where if we have fallen behind on our work, we have a week to catch up. However, if we are on schedule we will use this week to

Task	Week 11 Apr 6 - Apr 10	Week 12 Apr 13 - Apr 17	Week 13 Apr 20 - Apr 24	Week 14 Apr 27 - Apr 31	Week 15 May 4 - May 8
Project Work	Invite People for User Tests				
		Conduct User Tests			
	Implementation				
	Gold Plating				
Writing		Final Thesis			
		Results	Discussion		
					Conclusions
Research					
Other					

Figure 5.3: Planning for week 11 to week 15.

prepare for the presentation and finalizing the thesis. We do not exactly know when we will present the thesis. The general slots for presentations however are from the last week of May to the first week of June, so we need to be prepared to be able to present both of these weeks. Our aim is to hand in the final version of the thesis one June the 12th.

Task	Week 16 May 11 - May 15	Week 17 May 18 - May 22	Week 18 May 25 - May 29	Week 19 Jun 1 - Jun 5	Week 20 Jun 8 - Jun 12	
Project Work	Buffer Week (Preparing Presentation and Finalizing Thesis)		Final Thesis			
Writing		Future Work	Finalizing Thesis			
Research			Presentation			
Other		Preparation	Execution			

Figure 5.4: Planning for week 16 to week 20.

5.2 Risk Management

In every project there are risks, if discarded and managed early in the project it can avoid potential headaches later on. For this project we have identified several risks from design, to implementation, and personal matters in between.

Implementation The implementation of the design is always a risk as there might be technical problems arising. As we, the authors, have some experience with both Unreal Engine and Unity, we can easily address the riskiest factors of the implementations and do these first.

Sick Days There is always a chance that either or both of us will get sick during the project. In the best case scenario regarding this, the sick person can work from home, with daily Skype calls to support.

6

Execution

In this chapter we will take a look at the execution of the research project and explain the individual steps of the development process. First we describe the iterative development of the board game prototype and explain the finale prototype in more detail. Afterwards we describe the evaluation process of the prototype.

6.1 Design Concept 1: "Hinweis"

Our first prototype aligned more towards a card game than a board game. Inspired by the popular game *Clue*¹, 3-6 player are competing in keeping and revealing secrets. The players, referred to as guests in the game, would get personal objective cards and secret cards. The secret cards would be passed to another guest representing that two guests are sharing a secret. To reveal the secrets, the guests needs to find clues. They do so by moving their avatars around a game board and investigating objects in the scene. These objects may include clues to a secret. When a player feels like they have the puzzle pieces to expose a secret they can chose to do so on their turn. If they guess correctly the secret is exposed and the player earns victory points. If they fail, they lose victory points. The idea with this game was that all cards would have a number on their backside, and thereby creating a branching narrative with the cards. So for instance personal objective cards could have two outcomes, each of these outcomes could lead to further cards, and so on. This is the reason we did not continue the development of the prototype as we realised we would not have enough time to finish the game due to the branching narrative. While several ideas were discussed, we discontinued this prototype before we knew how exactly MAR would fit into the gameplay.

6.2 Design Concept 2: "Steal This Game"

Our second prototype drew new inspirations from the board games *Gloomhaven*² and *Dead of Winter*³. It did have some drastic changes from the previous design concept. While still relying on cards and decks as physical components and a source of controlled randomization, the board now consisted of multiple tiles, with new tiles being unlocked and added to the board as the players advance through the game.

¹<https://boardgamegeek.com/boardgame/1294/clue>

²<https://boardgamegeek.com/boardgame/174430/gloomhaven>

³<https://boardgamegeek.com/boardgame/150376/dead-winter-crossroads-game>

This was an attempt at adding a progression system as a motivational factor to the game. Other elements that were kept from the previous design concept were the idea of the players having a common goal, but also secret individual goals, as well as random events at the end of each round, to constantly progress the game.

In this game every player takes on the role of a thief and all players collectively form a team called guild. The collective goal of the team is to collect gold and donate it to the guild to increase the guild's prosperity level. Maximising the prosperity level is also the end condition for the game. However the players also progress through a variety of individual goals to collect victory points. These will determine the winner when the end condition is reached. The game is played in rounds and in each round every player takes a turn. At the start of a round all of the players roll three action dice each. One of them is used by each player to determine the order in which the players take their turns. The others can be used to perform three actions, each requiring the usage of one die. These actions are going on a raid, selling items, or stealing items from another player.

When a player chooses to go on a raid they first choose an area which they want to raid in. Every area has three raid slots, which are blocked for two rounds after a raid has happened there. Further each area has a deck of item cards from which the thief can steal during a raid, a list of which items are found in that area, a current and a global noise level which effect the raid difficulty, and optional special conditions. When starting there are only two areas available to choose for a raid, however, as the guild increases their prosperity level more areas are unlocked. When going on a raid two decks of cards are in use. One deck of steal cards, which is used for every raid and reshuffled after every round, and a loot deck consisting of item cards, which is unique to every area. First a card from the stealing deck is drawn which determines the noise made, and then a loot card is drawn, which is not shown to the other players. Now the player can choose to keep this card or discard it and then repeat the process or attempt the escape.

The escape difficulty is determined by the global noise in the area, the current noise in the area which was generated by the steal cards, any special conditions of the area and the amount of items held by the thief from the raid. The action die chosen by the player for the raid, plus the value of a newly rolled die added up have to be higher than the escape difficulty to escape without consequences. If this fails the players bounty is increased by the amount of items they hold and they get another attempt at escaping. Now they can again roll a die. The value of this roll has to be higher than the amount of items they hold. Before performing this roll, however, they can choose to discard any number of items to increase their chances of escape. Should the second attempt also fail, the player goes to jail, meaning they skip a number of rounds equal to their bounty level. However, while in jail, a player has one chance to escape every round, by rolling two dice. If the two dice show the same value, the player escapes jail.

When a player attempts to steal from another player, the targeted player has a chance to defend themselves. This is done by either using an unused action die of the same or higher value than the action die of the stealing player, or by using special items, which in this scenario have the effect of a die with the value five. When using an action die to sell an item acquired by raiding or stealing from another player, only

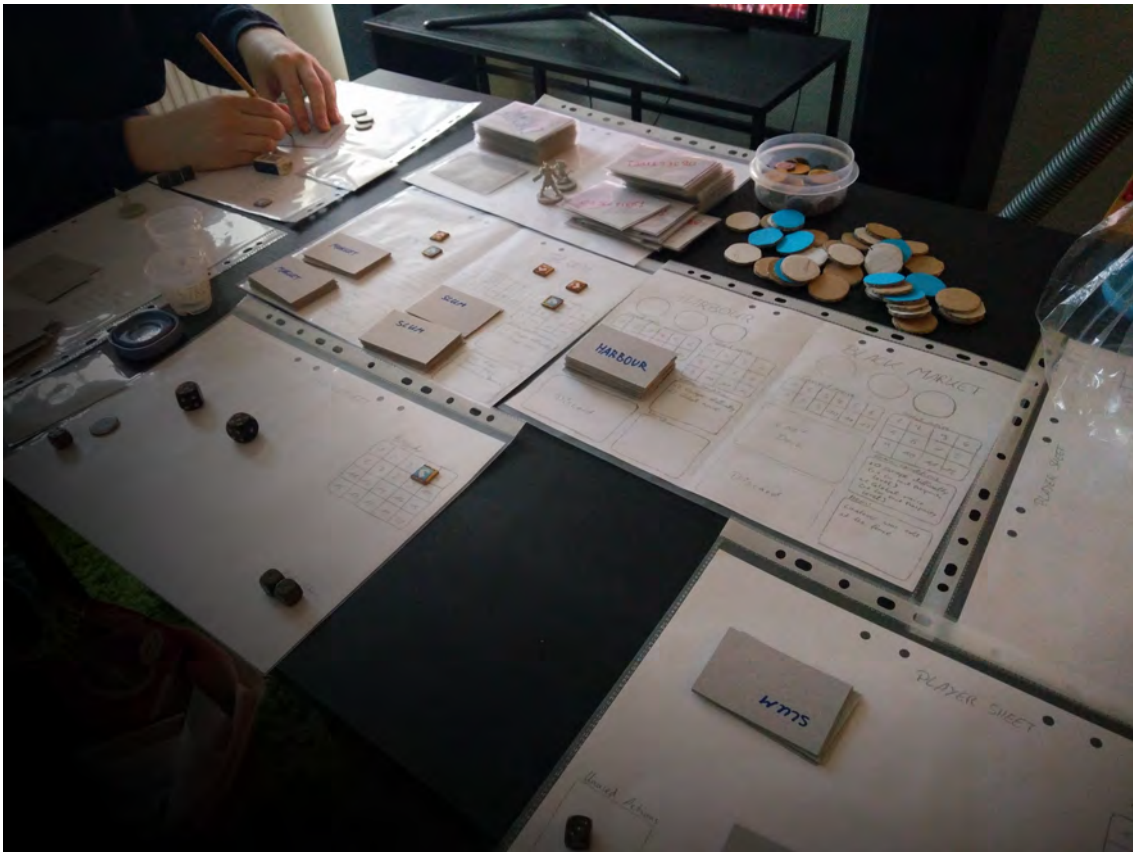


Figure 6.1: The developers testing the physical prototype of Steal This Game.

one item can be sold at a time. The item is sold in exchange for gold. Here the gold value is determined through the overall value of the item and the value of the action die used for selling, with a higher die value resulting in a higher gold value. Players can also initiate trades during their turn, asking to exchange gold and/or items with their fellow thieves. At the end of a round the players can discuss if and how much to donate to the guild. The last action to be done after a round is to draw an event card from the event deck. These events can either have an instantaneous effect, like a donation to the guild, or set up conditions for the next round, like decreasing the escape difficulty for all raids. Figure 6.1 shows a play session of Steal This Game in progress.

During a play test we found some issues with the current design. One is that we felt the objectives need more time to complete than we anticipated, which leads to the players progressing slowly. Overall the game seems to take quite a lot of time to complete. For the next design iteration we plan to make progression faster, that being individual player progression as well as overall progression of the game. Another issue seems to be that players become disengaged during other players turns rather quickly. This could indicate a lack of interest in the actions of other players, thus increasing the collaborative aspect of the game could improve that, as the player's stakes would be higher in the other players' actions. Additionally we will consider giving players the option to influence the outcome of another player's turn, e.g. through the usage of items. Another issue we found was that the players

felt they had too few actions to do everything they wanted. We need to consider if this feeling is desired, that the players have to ponder the options for their actions, or if they should be given more action dice, so that they can follow through with their plans more easily.

6.3 Design Concept 3: "Thieves: Wanted"

Continuing on the concept of Steal This Game, the final design concept emerged, called Thieves: Wanted. During internal play tests among ourselves and friends several issues with Steal This Game were discovered. One issue we found to be critical was that players quickly became bored when they were not having agency. This was especially true during the raids, when other players were looting, as this could only be done by one player at a time and the cards here were kept secret. So paying attention did not provide any significant advantages for the other players. Additionally, we found that the objectives in the game took too long to complete, so except for unlocking new areas there was little to no perceived progression, which made the game feel too long overall. Further we found, that while providing a strategical aspect to the game the action dice were too limiting, often leaving players unsatisfied at the end of a round. As we introduced the MAR component in this concept, we saw this as an opportunity to remove excise from the board game and creating an overall faster gameplay experience.

After several iterations we arrived at a game design we found to be worth evaluating.

6.3.1 Short Description of the Game Rules

The game is played over several rounds, where each round consist of two phases, the Day phase and the Night phase. The actions the player can take depend on the phase. The game begins with the night phase. At the beginning of the night phase an event card is drawn. When the night phase has ended the day phase begins. During the night phase, players go on Break-in missions using the AR application. These Break-In missions may result in the players looting items if they succeed, or increasing their individual wanted levels or even going to jail if they fail. During the day phase players are trading cards, and selling items, which is also called fencing, etc. Here the players can also pay gold into a shared bank between all players, also called sanctuary bank. Doing so can increase the prosperity level, which is a value shared among all players, and unlock new areas to go on Break-in missions.

The game can end in different ways, leading to different winning conditions. One way of ending the game is by reaching prosperity level 5. In this case the winner is the player with the most gold. However, the game can also end in other ways, for instance no loot cards being left in the unlocked areas or the players not being able to fulfill conditions for certain events. In these cases the winner is the player with the lowest wanted level.

A more detailed description of the rules is explained in section 7.1.

6.3.2 Design Motivations

In the following we motivate our major design decisions for this final version of this prototype, and relate them to the previous research.

Break-In Missions The Break-Ins are the element of the game in which the MAR component is involved in. Testing the previous concept, "Steal This Game", we felt, that this element was producing the most excise through handling of the noise and that players were most likely to lose interest during Break-Ins. For these reasons we found that this element would benefit the most from incorporating the digital MAR component. The Break-Ins were then designed to be interactive in real-time and to be executable by all players simultaneously. This way all players would have agency and even if started with slight delays no player would have to be inactive for extended amounts of time. The timer during the Break-Ins additionally ensures that no player will need much more time than the other players. Another reason for timing the Break-Ins and only utilizing the AR component during the night phase, was to make sure the players would not have to hold their phones for longer periods and have enough resting time between the uses. As it is typical for board games the game was also designed to rely on the social interactions between players, so we wanted to keep the MAR parts during which the attention would shift from the group towards the phones limited. To carry some sense for the group over into the virtual we implemented networking into the AR app, so that it is possible for the players to not only see their own avatars move, but the other players' avatars as well. Further, having the MAR component limited to only one element of the game allows the players to enact house rules in many aspects. The app also does not keep track of the physical game state, which enables the players to also enact house rules regarding the usage of AR to some extent, e.g. a novice player could replay a failed Break-In, as the app does not keep track of the amount of raids that happened or in which round or phase the group is in. The second escape is another aspect to the Break-In missions. This was added for two reasons. One was to have the novel MAR component closely tied to more traditional board game elements like rolling dice and drawing cards. Another was to add a element of risk reward gamble, instead of immediately punishing players.

Jail As punishment should the risk reward gamble of the second escape attempt during Break-Ins fail, a player goes to jail. While a punishment that should scale with the risk the players take, we wanted to still give the players some agency and the opportunity to lessen that punishment. For this we added two actions a player can take while in jail. One is a rolling of dice, allowing the player to escape instantly. This instantaneously removes the punishment, but is also completely based on chance, while again adding an element many players are familiar with, as it is quite common in board games. The other action allows a player shorten their time in jail, for increasing another players wanted level. This puts the player in jail, while at a disadvantage, into a position of power of sorts, as they have to some extend control over the length of their jail time, while also having the option to worsen another players situation. This should enable for interesting dynamics to

play out between the players.

Prosperity Level The prosperity level was designed to mainly serve two purposes. For one it should serve as the main progression system, which rewards the players by unlocking new areas and ultimately leads to successfully finishing the game when the last prosperity level is reached. Besides providing this long-term goal to the players it is also a common goal for the players, which should motivate collaboration. This should open up interesting social dynamics in the group and allow players to follow varying play styles, ranging from full collaboration and playing as a team to completely antagonizing and everyone playing exclusively for their own benefit.

Fencing Fencing and the resource management of item cards and gold involving it serve multiple purposes. Through the use of dice, cards and tokens, this aspect of the game emphasises the materiality of the physical game elements, which according to our research is important to the feeling of playing a board game. The handling of these physical elements, and looking up values in tables for fencing introduce chores to the game. While heavily dependent of the players themselves, dealing with chores can improve a board game experience and make it more fun. At the same time we tried to keep the chores at a rather low level when compared to other board games, to not put players off, that might be more intrigued by experiencing the AR aspect of the game. Additionally the act of fencing also introduces another gamble of risk-reward, as items can be lost through various means, while gold is a resource, which can not be taken from a player without their consent. However, the gambling aspect of potentially wanting to keep items rather than immediately exchanging them for gold and therefore risking to lose them, is implemented through the fence die, which randomly determines if items can be sold for a larger or smaller amount of gold. Here different items, also have different properties, as they have varying value increases, which may influence a players decision on wanting to keep them for a good fence roll.

Objectives We designed a progression system in form of the prosperity level, as the group of players unlock new areas this way. Additionally we added objectives for the players to complete as a way to create a sense of achievement for the players. However in Steal This Game the objectives took too long to complete and exchanging an objective was taxed with a cost of gold. This ultimately resulted in only few objectives being completed over the course of one game. As the players already have a long-term goal in the game, reaching prosperity level 5 and amassing gold, we wanted to design the objectives more as short-term goals, which would give them something concrete to do while they are making their way to reaching the long-term goal. That's why we redesigned the objectives to be faster to complete and free to exchange once per round and player. This way the players should be able to progress through several objectives in one play session. Further all objectives would reward the player with gold when completed, thereby also helping them to advance towards completing their long-term goal.

Exiling Exiling players is an action, which does not have to be executed to complete a game session and does not necessarily aid the players to reach their goals. However, providing the option of exiling players should enable a variety of group dynamics. We wanted to design a game which would allow for various social dynamics to play out, as research shows that the social experience is a major reason for people to play board games. Enabling a multitude of dynamics to take place would also increase the replay value and could therefore potentially serve as a motivator to play multiple sessions and an aspect leading to the desire to continue playing.

Levels Players should be able to have multiple options where to go to for their Break-In missions. This would allow for more variety and for players to make more decisions. For this reason we decided to design multiple levels. These levels were designed over multiple iterations.

The first iterations of level designs was free form with most lines being parallel to the edges of the image, but the distances between lines varied greatly and some lines were on different angles. For those levels to properly work the grid for the A*-pathfinding would have needed to be quite detailed. For performance reasons we limited the next level designs to follow a 20 x 20 grid. In virtual space we placed walls on the level outlines and placed further objects on unoccupied tiles of the grid. Some of these objects only serve as obstacles to create more narrow paths, while others were placed to be locations where loot could be found. More possible loot locations were placed in each level than actual loot per round, to be able to randomize the actual loot positions for every Break-In mission. To indicate where loot is located during a Break-In we added particle effects to those objects serving as loot locations

6.3.3 MDA and Gameplay Design Pattern Analysis

Following our established definition of player engagement we looked at various gameplay design patterns to find a set of patterns which could help to create player engagement. The set of patterns we built the prototype around were **Player Agency** [27], **Replayability** [30], **Social Dilemmas** [32], **Tension** [33], **Varied Gameplay** [36], and **Incompatible Goals** [24]. As the player should participate actively creating **Player Agency** [27] is fundamental. As the players should also be active in decision making creating **Varied Gameplay** [36] should allow players to make relevant choices and allow the game to play out in different ways. This alongside **Tension** [33] should also help to keep players focused and invested in the game. Creating **Replayability** [30] could help to keep players engaged even through multiple play session. **Social Dilemmas** [32] and **Incompatible Goals** [24] should help to create engaging social dynamics. Having established this core set of gameplay design patterns, we were looking for further patterns to instantiate the selected set. In figure 6.2 the most relevant patterns which according to the MDA model also act as mechanics are displayed and put in relation to one another. Figure 6.3 highlights the mechanics which instantiate relevant patterns we identified as dynamics and aesthetics. In the following we explain some relations which may seem curious or we think are crucial for creating player engagement in the case of Thieves: Wanted.

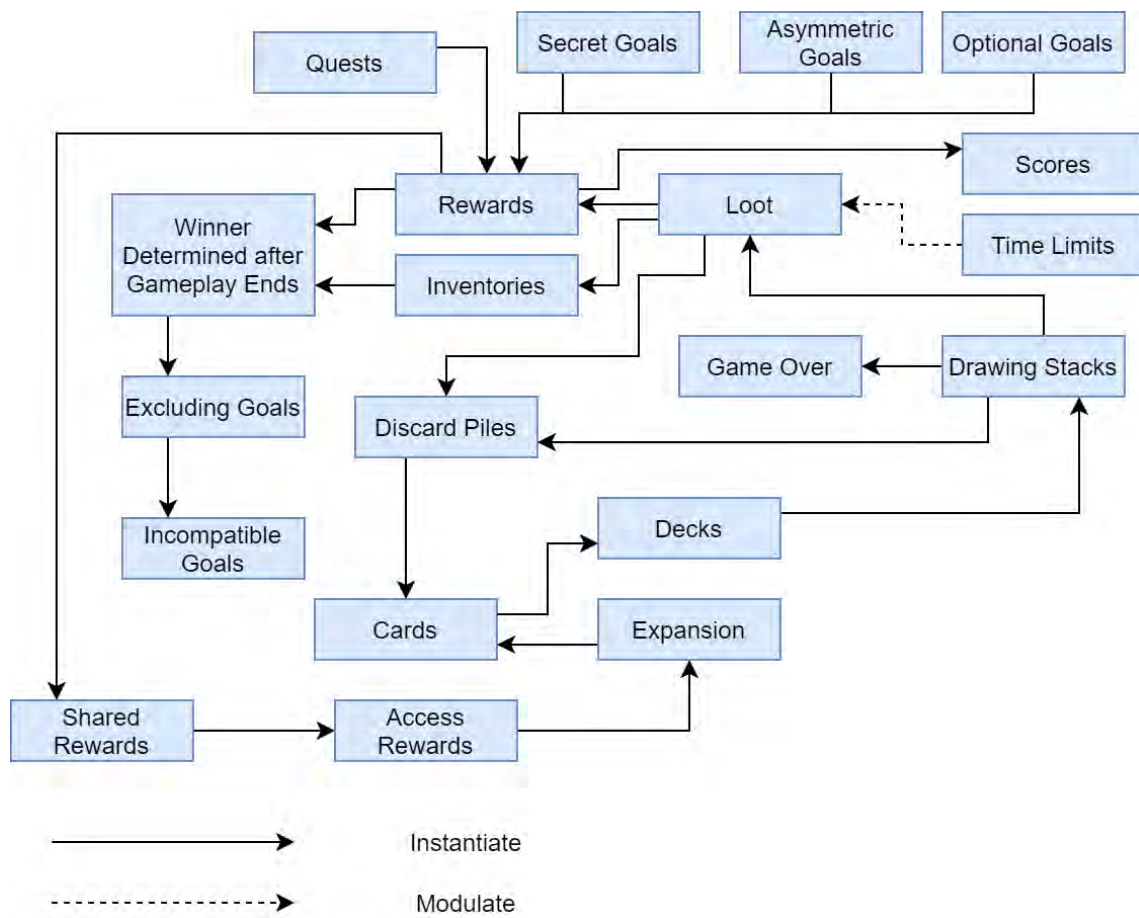


Figure 6.2: General game flow described by game mechanics following the MDA definition of mechanics.

in Thieves: Wanted. This **Randomness** [29] was mainly added to the design to encourage two types of feelings in players. The feeling of **Tension** [33] if something is decided by chance with minimal influence, and the feeling of **Luck** [25] if a player happens to get a desirable outcome from the **Randomness** [29].

6.3.4 MAR Application Implementation

In this section we will look at the implementation of the MAR application we developed for the game.

For the implementation we used Unity game engine, together with Vuforia for AR, and Photon Pun 2 for networking. The game required us to build level upon the markers which we would project geometry on using Vuforia.

Vuforia Markers First thing that needs to be established is the concept of a marker. A marker is something in the real world that the AR application can identify to create its relative coordinate system. In Vuforia there are several types of markers that can be used. The types of targets supported by Vuforia are Single Image, Cuboid, Cylinder and 3D Object targets. As we didn't see any advantage in experimenting with untypical and harder to design targets for the purpose of this research, we decided to use single image targets.

For the tracking Vuforia uses AR feature points. The tracked feature points are sharp, spiked, chiseled detail on an edge of a certain contrast. For a tracking target to be accurately detected and tracked, the image used should be rich in detail, have good contrast and no repetitive patterns. Another factor for accurate tracking is the feature distribution [61].

For designing the targets, the initial idea was to show the layout of the levels on the targets, similar to a floor plan. This would make the targets distinguishable and give the players an idea of what the levels look like before even starting the app. However, showing only the level outlines would not produce a sufficient amount of features to provide a satisfying accuracy in tracking, see figure 6.4a.

For the next iterations of markers we would generate images using the Augmented Reality Marker Generator by Brosvision [2]. We would combine the randomly generated images with the level outlines and have the outlines highlighted by using thicker lines to keep the targets more distinguishable to humans, see figure 6.4b.

For the last iteration of targets we used the image editing program GIMP [37] to manually add details to image to further increase the feature density and make them more evenly distributed, see figure 6.4c. This would allow the tracking to remain relatively accurate even when the players move the camera so close to the target that some of it might not be in the camera's view anymore.

Pathfinding The native pathfinding for Unity, navmesh, does not work with AR, due the use of pre-computed mesh. But since we do not know where the origin point is changing we cannot precompute the pathfinding. Therefore we need to implement our own pathfinding system. For this we implemented a gridbased system using A search algorithm. We created the grid during runtime.

We created markers using Gimp which we initially printed out.

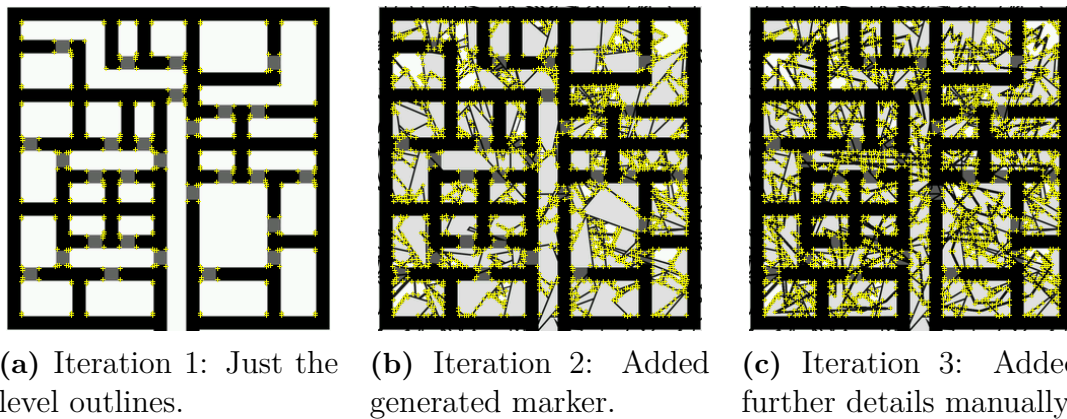


Figure 6.4: The iterations of the image target design. A yellow cross indicates a feature point registered by Vuforia.

The current version of Unity has no built-in supported networking service. Due to time constraints we felt like building our own networking system was not a good idea.

Due to how AR works an immediate problem is where is the origin point in the world, and how is the coordinate system used. Vuforia itself has several settings for this, for instance, you could set the origin point based around the camera, or the first identified picture of the world. We wanted to have a system independent of Vuforia's coordinate system. The way to achieve this is relatively straight forward. We just need to make all objects within a level as a child of the Vuforia marker. However, there is a problem, in terms of networking. The reason, is that we cannot mirror the hierarchy between the different clients. To solve this we had to implement a new hierarchy on top of the Unity's hierarchy system. There were a lot of different corner cases here and there to solve, which took a large amount of the planned time to solve.

Interfaces in AR During the Break-In Missions there were multiple values we wanted the players to be aware of. Those values are the timer, the created noise and the amount of collected items. Different ways of displaying these were discussed and tested. According to Google's Design Guidelines for AR regarding Interaction, 2D interfaces should be avoided if possible, as they would break the immersion and remind the user that the augmented content is just virtual.

We tested displaying the timer as well as the noise as circular fill bars in world space at the base of the player avatar. During testing we discovered that sometimes situations would occur in which the fill bars would be obscured by 3D objects in the scene. As both of the values are important for the player to determine how close they are to the end of the Break-In, we felt that they should be visible to the players at all times during the Break-In Mission.

We decided to place the noise as a fill bar hovering over the player avatar. This would allow the value to always be visible when the player avatar is in the camera's view, as well as serve as an identifier to easily differentiate the player's own avatar from other avatars. While we decided having the noise only visible when the avatar

is in view was sufficient as the noise only increases when the player does certain actions, we felt that the player should always be aware of the timer. For this reason we placed the timer in form of a counter in screen space at the top of the screen.

While this goes against the recommendations by Google, we felt the player being aware of those values at all times and knowing those values accurately was more important to the gameplay than upholding the immersion in AR by obscuring the values in some way or not showing them at all.

We discussed ways of displaying the amount of collected items in some form at the player avatar in 3D space, but we decided that the implementation would cost too much time and would not be worth it since we already had a 2D interface for the other values. For this reason we decided to place the amount of collected items with the noise.

6.4 Evaluation Process and Planning Changes

Due to the corona virus (COVID-19) spreading throughout Sweden during the time of us working on the thesis, our planned face-to-face user test was ethically problematic. Since our user test revolved around testing the game with a group of people simultaneously in one location, we viewed this as a critical risk during the crisis. After discussing alternatives with university staff we instead opted to conduct an expert analysis. This would change the evaluation process as a whole as well as the results. Instead of observing actual play sessions and interviewing novice users, we interviewed experts, who analysed the game but haven't actually played it. Due to the lack of an actual play session, the playability of the prototype and minor issues in the gameplay may not be as relevant in the discussion. Further, talking to experts instead of novice users required a different way of conducting the interviews as well as interpreting the answers. While conducting actual user tests could have provided more quantifiable data, the insight from the experts might have revealed some aspects that could otherwise have gone undiscovered.

There was still a question of how these expert's would be able to access the physical game. First we thought we would just send the game via post to the experts. However the problem with this is that we only had one physical copy of the game, and because of this the expert analysis part would take much longer than what we had planned for. The next idea was to compress the game into a printout pdf document, so the experts could print out the game from their home. However, after asking the experts beforehand, we realised that not all of them had access to any printers.

As a last option we resorted to making a replica of the game using Tabletop Simulator. Tabletop Simulator is a sandbox game where you can quickly create and play any type of board games.

6.4.1 Digital Implementation in Tabletop Simulator

To replicate the previously physically designed board game in Tabletop Simulator, we first had to familiarize ourselves with the sandbox game. After first understanding the interface and getting familiar with the various components already provided

by the game and how to interact with them, we could select suitable components to start replicating Thieves: Wanted.

Tabletop Simulator provides a variety of dice by default, so we could choose differently coloured dice for the fence die and the player dice. For the gold tokens we used white Go pieces, as they come in a bowl, which in the simulator is a source of infinite pieces. For the sanctuary bank we used an empty bowl, in which players could place the gold tokens. The counters for the wanted levels and prosperity level were previously handled with tokens, however the Tabletop Simulator offers virtual digital counters which we used to replace the token counters. While the token counters could be a desirable element in a physical board game over a digital counter due to the materiality of the tokens, we felt in the setting of a virtual environment inside Tabletop Simulator a digital counter would be preferable as it is easier to interact with and the benefits of token counters are not present in the virtual space.

In the physical version we intended to have some way for players to hide their currently held amount of gold from the other players, by either providing pouches, privacy screens or something similar. While not in Tabletop Simulator by default we found privacy screens in Tabletop Simulator's workshop, which is a virtual place where player created content can be exchanged. However, the actual practicality of the privacy screens is debatable, as players can move their viewpoint in virtual space without the other players noticing.

For the card decks and the tracking targets we had to generate custom components. For the tracking images we used custom tile components. These were easy and quick to create, as we already had the image files for the tracking targets and the tile components only require one image. For the various card decks we used custom deck components. The custom deck component requires one image file including all of the card fronts in that deck and one image file for the card back. Tabletop Simulator provides a tool which will generate a compound image file for decks out of the individual card files. We again used GIMP to create all of the different card fronts, which we could use as input to generate the deck image file, and a unique card back for each of the decks. Those files we could then import into Tabletop Simulator to create the custom decks. Once this was done and all of the required components were present, we would adjust the scales of the individual components and wrote descriptions for each of them, which show up when hovering the mouse over a component.

6.4.2 Expert Analysis

The experts where given access to the game in Tabletop Simulator and the MAR application. Along with those we send them documents containing the rules (seen in appendix B.3 and B.4), a set of questions to keep in mind during the analysis (seen in appendix B.1), and a additional information about the recording of the interview (see in appendix B.2). As this is not a user test of any kind we were not as formal with the analysis, so the experts could ask us questions about the rules and so forth through the entire session when they where looking at the game. The experts evaluated the application, looked at all of the rules, and all of the cards we had produced. This was done to give the experts a feeling of what the game was



Figure 6.5: The start setup of *Thieves: Wanted* in Tabletop Simulator for four players. The board game components are: (1) objective cards deck, (2) event cards deck, (3) wanted level counters, (4) privacy screens, (5) gold token source, (6) fencing die, (7) player dice, (8) slum loot cards deck, (9) slum level marker, (10) market level marker, (11) market loot cards deck, (12) sanctuary bank, (13) prosperity level counter, (14) black market level marker, (15) harbour level marker, (16) harbour loot cards deck

about. The experts analysed the game with us available to answer questions for about 45-60 minutes. After a short 10-15 minute break we recorded 20-40 minute long interviews, which as of the publication of this thesis, are destroyed to ensure the privacy of the individuals. In these interviews we used the questions previously send to the experts as leading questions. However, we tried to develop discussions by reacting and asking further questions depending on the experts answers. The results of these interviews are presented in the results chapter of the thesis.

6.5 Interviews

We invited several experts to evaluate our game, *Thieves: Wanted*, both from companies and from universities. In this thesis these experts will be labeled anonymously as: Expert "Frank", Expert "Johan", Expert "Kalle", Expert "Hans", and Expert "Bill". During the interviews we asked the same five leading questions to all experts:

- Do you think players would feel physically or emotionally uncomfortable using the smartphone playing the board game?
- Do you think that the AR feature takes away the feeling of playing a game

together with other players?

- What do you think would be the largest motivational factors for players to start playing the game and wanting to continue playing the game?
- Which aspects of the game would make a player want to stop playing the game?
- Do you think AR is unnecessary for the game flow?

These questions were handed to the experts before the analysis. During the interview these were the questions discussed, however, follow up questions varied depending on the answers given.

The answers will be presented sorted by expert and topic.

6.5.1 Expert "Frank"

Expert "Frank" is a master student of game design and technologies, with a master's degree in information technology.

Do You Think Players Would Feel Physically or Emotionally Uncomfortable Using the Smartphone Playing the Board Game? Expert "Frank" said regarding the physical comfort "since I was playing the simulator on the monitor it was a bit uncomfortable", referring to playing the game in Tabletop Simulator and further explaining that as the phone was close to the face and holding it at that angle was straining with time. However, they think playing the game on a table surface would probably be more comfortable, stating "it would probably be much better on a table". Expert "Frank" also stated, that they did not experience their arms or hands getting tired over time, as the break-in missions were quick and the day phases allowed for some resting time, and added that especially with more players this resting time would be even longer. Further the expert said, that if a player was to start feeling uncomfortable using the app, it would be thematically fitting as they are a thief and their dexterity would be tested.

For the emotional comfort of the players, Expert "Frank" does not see any problems.

Do You Think That the AR Feature Takes Away the Feeling of Playing a Game Together With Other Players? "I do not think that I would feel disconnected from playing with others". As the AR feature is only "one small part of the turn", expert "Frank" does not see how it would disconnect from playing with other players. The expert compares the break-in missions to actions like rolling a die, which every player would just do for themselves, just taking up a little more time, and thinks it would only cause a small disconnection from the whole round. Besides that Expert "Frank" is of the opinion, that the prototype would feel like a regular board game, involving a lot of communication between the players. When asked if simply having mobile phones around could be distracting from the game, Expert "Frank" said "usually now when you play tabletop games you probably always have phones around you", explaining that the simple fact that phones are present during a session of Thieves: Wanted would not disrupt the social interactions any more than in any other situation. Additionally expert A stated, that mobile devices are around us all the time, even when we play other tabletop games, so the simple

fact that phones are present during a session of Thieves: Wanted would not disrupt the social interactions any more than in any other situation.

What Do You Think Would Be the Largest Motivational Factors for Players to Start Playing the Game and Wanting to Continue Playing the Game? Expert "Frank" was of the opinion, that "before playing the game, just having the label on it that it's AR-based" would pique interest and people would generally be intrigued by the novelty of a MAR board game, which could attract potential players to picking the game up.

Aspects keeping the motivation up during a play session, according to Expert "Frank", are collecting and hoarding money and the test of skill during the break-in missions, saying that "it basically turns out to be a bit competitive". Expert "Frank" highlights the competition on top of the communicative aspects of the game as being the long term most motivating parts of the game and more interesting than the AR component.

Which Aspects of the Game Would Make a Player Want to Stop Playing the Game? Expert "Frank" mentioned, that "it's a bit hard to navigate on the map" referring to navigating the avatar during the break-in missions in AR, further explaining that the UI hovering over the avatar was taking up too much space, blocking the view and taps. The expert added that they would have preferred playing the break-ins in landscape mode over portrait mode, which should have been supported by the app.

Another aspect, which could potentially turn players off would be the jail, according to Expert "Frank". "When you are in jail you have nothing to do and you need to wait for so long". They said, that while they see that the jail should be perceived as punishing, players in jail would have too little agency. Expert "Frank" adds, that other games, which include a jail, e.g. Monopoly, typically have quicker rounds, as the players often just roll a die and move their token. For this reason, Expert "Frank" is of the opinion, that the time in jail could be perceived as too long by the players, and having an upper limit for the jail time should be considered. The expert added that since the phones are at hand anyways, jailed players may engage in other activities using their phone, thereby removing themselves from the game even further.

Do You Think AR Is Unnecessary for the Game Flow? Expert "Frank" described the AR component of the game as a nice addition, but stated that "the AR in this case could be sufficiently replaced with just an application". They said that the digital feature adds a test of skill and reaction time, which would be harder to replicate in a pure board game, and replacing it with elements of randomness like dice rolls would change the experience. When asked if the game could work as an entirely digital game, Expert "Frank" stated, that it would probably end up being a very different game, adding "I think it works as a board game".

Further Expert "Frank" said, that the break-in missions and the usage of the app felt like a main mechanic of the game stating "the mobile usage here is important", but added that the AR app could be replaced by a mobile app lacking AR without

changing the experience in a significant way. The AR app would not require the player to use the physical space, as according to Expert "Frank", the break-in mission were best played from a top down angle. When asked if moving in the physical space to change the camera and be able to view things previously blocked by the hovering UI, Expert "Frank" responded, that this issue would potentially not be present in the first place in a purely virtual app.

Concluding Expert "Frank" said, that while the digital augmentation of the game is definitely an important part of the game experience, AR would not be necessary, and an entirely virtual app would possibly be enough to replace the AR app, if not even provide a better experience.

6.5.2 Expert "Johan"

Expert "Johan" works as a programmer at an indie game company in Sweden.

Do You Think Players Would Feel Physically or Emotionally Uncomfortable Using the Smartphone Playing the Board Game? "I do not think people will be uncomfortable using their phones." He stated as the game was quite short, with the time limit being 45 seconds which he did not believe would add any strain to your arms. "So many people are comfortable using their phones for any day tasks, communicating, reading etc."

Do You Think That the AR Feature Takes Away the Feeling of Playing a Game Together With Other Players? "Yes I think so. Especially when it is a table-top game. For me the point is to gather a group of friends and interact, not through a computer." He continued that it still interesting in the terms of game design, as more games can be created, but it would still pose a disturbance to the social aspect of playing games. He thought that the disturbance would be less with AR headwear, like microsoft HoloLens 2. Because it would remove the disconnection feeling, of shifting between AR mode and the board game.

What Do You Think Would Be the Largest Motivational Factors for Players to Start Playing the Game and Wanting to Continue Playing the Game? "The cooperative theme of the game was certainly interesting." They said that the AR gave some interests to the game, however that the game could work without the AR. As they did not think that AR was the biggest factor that would motivate people to play the game. We asked him if he thought that someone interested in Pokémon GO and board games would be likely to be interested in playing a game like our prototype, to which he responded: "It might give interest to some people, then if the game is good the word is going to spread, whether how good, or how bad these AR features are. I do not think a regular board game player would be interested in it just because of AR features, but if they have heard that the AR adds to the immersion of the game then it could add extra interest."

Which Aspects of the Game Would Make a Player Want to Stop Playing the Game? The expert said that the exile feature of the game did not sound very

fun. However, he said that it could depend on the group dynamics. We then started pivoting the conversation towards AR. He complained about the power conception of the application, as it nearly drain all of his power during the play evaluation. However, if the phone could keep up with the application he did see that the AR would not be a problem. However, he said he would also like to play the game for a longer period of time to answer the question. We asked the expert about social dynamics regarding AR head-ware, if that would be something people would mind wearing while playing the game. The expert said that this was something he would prefer over the smartphone. However, one issue he stated is you will still need some controller to control the game which might cause certain annoyances.

Do You Think AR is Unnecessary for the Game Flow? "If you redesign the mini-games it could work without the AR. But on the other hand, if you expand on the mini-games, making them a much bigger factor that may out weight the other interest points." We continue the interview by asking him if he saw the AR features of the game as a gimmick, to which he replied with a yes. Further we asked what he though if we made the game into a pure computer game. To which he replied: "Instead of having one mini-game, having more randomized much more elaborate mini-games, which are not just point and click would be more interesting." He gave an example of Nintendo's Mario Party series. He said that games of that style could be fit into this application, but you are still at a table top playing them. If that was the case the AR would be come much more of an interest. "In terms of AR, it does not contribute enough to make a solid selling point for the game." We asked, regarding ergonomics in regards to his ideas, if this would be straining on your hands having a lot of these AR mini-games. He said that removing the timer could be a good thing, so people can put down there phone whenever they want to, so that they do not feel forced to hold the phone in a uncomfortable position. At the same time, he though that people are so used to playing games on their phones nowadays, while on the toilet, or on the bus home from work, that it might still not be a problem.

6.5.3 Expert "Kalle"

Expert "Kalle" works as a programmer at a company in Sweden.

Do You Think Players Would Feel Physically or Emotionally Uncomfortable Using the Smartphone Playing the Board Game? He said it did not feel natural from the beginning to use the phone during the evaluation, but something that one could get used to. Regarding the emotional, he did not see any problems with it, as long as everyone in the board game party is aware of the AR features. The expert confirmed that he had experience with Microsoft HoloLens 2. We asked if he would have preferred to use head-ware instead of a smartphone. From the expert's experience with HoloLens, he though that the HoloLens in particular had a very limited field of view. This makes AR a bit weird using the head-ware, since not all of your eyesight is covered by the AR screen.

Do You Think That the AR Feature Takes Away the Feeling of Playing a Game Together With Other Players? The expert explained in regards to the idea of future headwear, where the field of view is not a limitation. He thought that it would not take away the feeling of playing a game together due to the fact that you would still be able to hear the other players, and that would give you some sense of direction.

What Do You Think Would Be the Largest Motivational Factors for Players to Start Playing the Game and Wanting to Continue Playing the Game? "I am not huge table-top gamer, but the feeling I got from this game was that it was not super complex." He thought that the complexity of the game was very balanced. He said that after a few turns he would understand and get into the flow of the game. He thought that the AR mini game was a fun addition to the normal board game. The expert felt like he was more immersed into the game, and that the AR added an additional dimension in terms of gameplay. We concluded the questioning by asking him why he would like to play another round of the game to which he answered: "I liked the mixture between collaboration and competition, as you could help each other out, but you would not know the agenda of why the other players would like to collaborate, as they have their own agenda and strategy." He also liked the positive outcomes of negative actions, such as intentionally going to jail to get gold from completing an objective. He said that the social part is what would motivate him to play the game in the long term.

Which Aspects of the Game Would Make a Player Want to Stop Playing the Game? The only thing that came up was regarding the exiling of players. He did not think it sounded fun, to target different players for exiling. He said that potentially it could be interesting if handled well within the group, but potentially it could be a deal breaker for players. In terms of AR there was nothing that the expert mentioned regarding this question.

Do You Think AR is Unnecessary for the Game Flow? "No I do not think so, I think it is a breather." He thought that it gave a nice contrast to the traditional board game mechanics of the game. We asked if he would prefer to less or more AR parts of the game. He said that having the AR parts further apart it could make them more special, as playing the AR mini game every round was a bit too excessive. We asked him if the AR parts of the game could be replaced, with some traditional board game mechanics. He said that potentially yes, that they could be replaced, but he did not really see a point of doing so. He thought that if the prototype was more polished it could be very fun playing the AR mini game. He thought that the AR parts of the game gave the game its identity. We asked if the AR parts should be bigger and more complicated or smaller and easier. "Even though the game was simple, there was still a lot going through my head in trying to optimize the best possible path." He thought that the game was challenging enough for him, but with more experience, it would maybe be a bit too easy. Maybe guard could be added, in the later levels to make it a bit more challenging as the game progresses. But overall he thought that it was very balanced in terms of challenge.

6.5.4 Expert "Hans"

Expert "Hans" is a master student of game design and technologies.

Do You Think Players Would Feel Physically or Emotionally Uncomfortable Using the Smartphone Playing the Board Game? "I do not see it as an issue", was experts D response regarding the emotional comfort. They explained the reasons as "everybody is in context" and "you are probably somewhere indoors". Further Expert "Hans" stated, that as every player participates in the same actions no one would stand out.

"Physically it can get a bit annoying". About the physical comfort Expert "Hans" explained, that they would imagine that when played on a table the players would have to stand up and lean over the table to position themselves in a way that the AR could function properly and to be able to execute proper inputs, as narrow corridors could be blocked from certain angles. Expert "Hans" added that they "had a lot of missclicks" explaining "I do have shaky hands, but I'm guessing I am not the only one" and stated that another reason was them rushing due to the timer. Expert "Hans" also mentioned the touch controls being too inaccurate for the levels, saying "I was pretty sure I was hitting the coins, but I was not". "It became frustrating after a while." Additionally the expert said "most importantly it was the user interface of the player getting in the way", referring to the billboarded world space UI. They elaborated that the UI was blocking the view, keeping the player collecting loot next to each other and said that it would probably better be placed somewhere static or not shown at all during the break-in missions and only presenting the results at the end.

When asked if the use of a headset would improve some of the physical issues, Expert "Hans" answered "maybe the experience gets better, but it brings a whole storm of problems". Expert "Hans" explained the main problem to be the accessibility of those devices, while basically everybody would have access to a smart phone. When asking about potential emotional impacts of using headsets in a group of people, the expert said it would pretty much depend on the group of people, as if the people would know one another it would not be an issue, but in public spaces or if strangers were around individual players could feel uncomfortable. Expert "Hans" added that headsets would also restrict where the game could be played.

Do You Think That the AR Feature Takes Away the Feeling of Playing a Game Together With Other Players? "Absolutely not." Expert "Hans" explained "you are not glued to your phones, you only have that for one particular thing". They further stated that the AR can even enhance the experience of playing together, as the real-time and more skill-based gameplay could make players frustrated or irritated more easily, which would create reactions and verbal communication in the group. While saying that it might be a downside that there was no shared view as every player has their own screen, the players would still be in the same location verbally communicating and creating a shared experience through their reactions. Expert "Hans" reiterated "No, I really really don't think that it takes away from the feeling of playing together with others".

What Do You Think Would Be the Largest Motivational Factors for Players to Start Playing the Game and Wanting to Continue Playing the Game? "The AR gimmick surely makes it unique." Expert "Hans" said, the AR component would raise peoples' interests, however, he could imagine the break-in mission getting boring after some time. Regarding long-term motivators the expert stated "it's mostly the blending of PvP (player versus player) and PvE (player versus environment) aspects". They elaborated that the objective and event cards would encourage the players to shift their focus between antagonizing and collaborative playstyles and added that options like exiling players would generate discussions among players and require them to adapt to different situations. The expert concluded "the AR can be the initial hook, and the PvE-PvP shift would be the 'wanting to continue playing'".

Which Aspects of the Game Would Make a Player Want to Stop Playing the Game? "I think the digital aspects are your main cause of alarm here", stating the players feeling physically uncomfortable using the AR app could lead to them not wanting to play for extended periods. The expert stated other potential reasons to be technical issues, slow phones or the phones heating up. They elaborated, that if only one player had a phone that would not run the app well it could ruin the experience for the whole group and that the phones battery lives also set a timer for the entire session.

Do You Think AR is Unnecessary for the Game Flow? "AR can be unnecessary, because there is not enough of a bond between the physical world and the digital world". Expert "Hans" said the AR app could easily be replaced by a completely virtual app showing the levels from a top-down perspective. They elaborated that AR could be essential if changes in the physical world would significantly influence the virtual content, adding that the levels would be too static and would always be the same. The expert also said that currently the AR component and the physical board game are easily separated. However, Expert "Hans" stated that some sort of digital component "is necessary for the identity of the game". When asked what they would change about the game, the expert responded the most important aspect to be to "tie together the AR with the game more tightly" and said that using digital skill-based gameplay in more parts of the game, e.g. trying to escape the prison, could also be interesting.

6.5.5 Expert "Bill"

Expert "Bill" works as an artist for a German game developer and previously completed their studies in the field of interactive media and transmedia game art. The interview with Expert "Bill" was held in German. The quotes were translated by us, trying to translate as literally as possible without changing the meaning. The translations of the quotes were discussed with Expert "Bill" to ensure their meanings were not lost in translation.

Do You Think Players Would Feel Physically or Emotionally Uncomfortable Using the Smartphone Playing the Board Game? "Yes and no", Expert "Bill" answered shortly. They elaborated "Physically yes, emotionally not necessarily, if the phone provides a cool aspect to the board game, then no". Expert "Bill" further explained their answer regarding the physical aspect, saying having to pick up the phone often could get annoying over time and that "everything is just incredibly fiddly and detailed on the screen and therefore appears to be too complicated." The expert added, that the controls felt imprecise.

Do You Think That the AR Feature Takes Away the Feeling of Playing a Game Together With Other Players? Expert "Bill" said "no, not necessarily". The expert elaborated "the way it plays now is in itself cool I think, but what is missing for example is a shared aspect in AR". "Everyone is seeing only their screen", Expert "Bill" commented, saying that having more shared information or some kind of interaction between the players in the virtual space, could improve the feeling of playing together. Later the expert also stated, that "the weakness of everyone looking at their own screen, is at the same time the strength", if used to e.g. show players information only they should have access to, or perform actions secretly. Further Expert "Bill" said, that while the players may be focused on their phones, they are still in the same location, being able to hear and react to one another. They added that "specifically with board games, so much depends on how the people are playing. You just never know how they are playing". Expert "Bill" explained that if certain player behaviour is desired, it requires special considerations on how this behaviour can be encouraged.

What Do You Think Would Be the Largest Motivational Factors for Players to Start Playing the Game and Wanting to Continue Playing the Game? First Expert "Bill" stated, that a reason for players to start playing a game over another game would be a unique selling point. Further they said, that the feeling of acting as a thief would be a motivational factor, stating "you are surrounded by people, who actually help you, but you never know when they will actually cheat on you and act in their own interest". Expert "Bill" added, that the most compelling aspects of the game right now, are the social dynamics, moral dilemmas, and that the players have so many options that one never knows what will happen in the next round. When asked specifically, if they don't think that the novelty of AR would raise the interest of some people, Expert "Bill" responded that they think what most people will see is that "it's more complicated than a regular board game". Expert "Bill" is of the opinion, that "AR by itself is not a selling point" and that it would make starting a play session more complicated, especially for beginners. They further elaborated, that a digital component has the potential to be a selling point if, for instance, it increases the replay value drastically through randomization, procedural generation, or similar techniques.

Which Aspects of the Game Would Make a Player Want to Stop Playing the Game? Expert "Bill" said, the preposition of the break-ins raises expectations and piques the interest, but the actual gameplay was disappointing, stating "it does

not feel exciting". The expert is of the opinion, that the break-in missions could feel repetitive over time, as they never really change, which could lead to a loss of motivation. However, expert "Bill" added that the break-ins have potential, but the actual application does not exploit that potential yet. The expert said conclusively "the interpersonal dynamics are currently the strength and AR is the weakness" of the prototype.

The expert also mentioned, that while the exiling of players may seem worrying in that regard, they actually think there is a lot of potential in the exiling feature, if the player is not only excluded from the group, but instead has some new options that previously were not there, putting them in a special position.

Do You Think AR Is Unnecessary for the Game Flow? "Currently it is definitely unnecessary." Expert "Bill" elaborated that "something is just simulated, that ultimately does not need AR" and said it could easily be replaced by a purely virtual app. The expert added that in this prototype AR would feel like an unnecessarily complicated interface for user interactions and said that the advantages of using AR with the current design are not evident. Expert "Bill" raised the questions about using technologies: "What purpose does the technology have? Like, why do I use it? Which strengths do I want to draw from the technology, so to speak?" The expert stated that from their experience AR applications often feel gimmicky and static, and sees a similar issue with the prototype. In the expert's opinion the AR component would feel more essential, if modifying the physical space would have a more significant impact on the virtual augmentation, or if the AR would simply utilize the three dimensions in physical space more, as right now it would only project small 3D objects on a 2D surface. Expert "Bill" further added, that a digital augmentation does add to the gameplay, as it has large potential to create thrilling risk-reward scenarios and time pressure, which in their opinion is a core element of the gameplay experience of *Thieves: Wanted*.

6.5.6 Interview Evaluation

The experts conducting the expert evaluation had varying opinions on some topics. Here we discuss the various answers we received during the post-analysis interviews.

Do You Think Players Would Feel Physically or Emotionally Uncomfortable Using the Smartphone Playing the Board Game? Due to the experts having to play the game using table top simulator it was a bit hard for them to assess the comfort of the game. As Expert "Frank" said it was uncomfortable holding the phone at a straight angle towards the monitor. The experts had to imagine how the game was supposed to be played on a real physical board. When Expert "Frank" imagined this scenario he thought it would be more comfortable. Expert "Johan" said that people are used to playing games on their phone for longer periods, for instance on the bus home from work. However, Expert "Johan" compared the AR application to regular phone games, in terms of ergonomics, which does not necessarily translate into AR applications. Because, in regular phone games without gyrosopic functionality, players can hold the phone at any position they feel is comfortable. However,

in AR games, the position and rotation of the phone relative to its AR tracking features, is often highly relevant for gameplay. Expert "Hans" shared more insight on that issue. The expert stated that it could get annoying, due to players having to lean over the table to get a good view of the levels. This was something we suspected due to our own playtesting from the physical prototype of the board game. Another issue that we considered during our tests was the frequent loop of picking up the phone, unlocking it, potentially pulling the app from the background, play the mini game, and locking the phone. Expert "Bill" mentioned, that repeating this process multiple times, could get annoying. This was an issue where the the experts were in disagreement, as Expert "Johan" stated that people where so used to using their smartphones, that they would not feel uncomfortable. Expert "Kalle" felt that it was initially uncomfortable, but that this was something that you could get used to, however Expert "Kalle" was talking mainly from his experience with Tabletop Simulator, and not the experience of playing it on a physical board.

Expert "Hans" felt it was hard to navigate in the game. The expert described that they had "shaky hands" which made it hard to click on where they wanted to go, which made the AR game quite frustrating. We felt during our own play tests that the levels were complex, meaning they would show a lot of virtual content on a relatively small physical space, which required the camera to be positioned close to the tracking target to enable somewhat precise navigation. When we made the game we did not take into account the impressions of touch controllers compared to a cursor, which we believe is the issue regarding the difficult navigation. The obvious solution would be to either make less complex levels or make bigger markers. However, another solution could be to cast several rays and make an approximation based on weights. For instance, points of interest would have a higher weight, in the case of our game, these would be exit points and loot.

While multiple experts mentioned the break-in missions being hard to navigate on the phone screen, Expert "Hans" as well as Expert "Frank" highlighted the player interface as an obstacle, obscuring too much screen space and blocking relevant parts of the level. Suggested solutions by the experts were, placing it at a static position in screen space instead of a billboarded world space interface, or not showing it at all. The latter suggestion closely corresponding to the Google AR guidelines, which recommend not to use any graphical user interfaces. While this may be easier to implement for other experiences, games often rely on these interfaces to communicate information relevant to the gameplay. As the expert evaluation as well as the Google recommendations show, new ways of communicating information like this other than just moving the interface to world space need to be found for MAR. The main issue of the world space interface seemed to be that it was taking up a lot of screen space, so new solutions should aim to avoid that. Ideas could be trying to work more with sounds or working with visual feedback in world space other than interfaces.

We asked the experts if they would prefer headwear instead of a smartphone to play the AR game. Expert "Kalle" was the only one of the experts with experience using an AR headset, namely Microsoft HoloLens 2. The expert pointed out that the headwear had a limited field of view, where certain area of the glasses show the world through an AR perspective. Here the center of the field of view would always

show the combination of augmented content and the real environment, whereas in the peripherals of the field of view there would only be the real environment, lacking any virtual content. This could lead to virtual content noticeably disappearing and in some instances even make it hard to differentiate between real environment and virtual content.

We set up a scenario for the expert to analyze, regarding the emotions with AR headwear. We asked them: "if you are having a board-gaming night with some friends, and are having some beers, do you think this would be something people would be willing to wear to play a game?" Expert "Hans" said that maybe the experience gets better but it brings a whole storm of problems. Where the main issue is the accessibility to these highly expensive devices. This was our motivation for using smartphones over headwear for this thesis. However, ignoring the fact of accessibility, the expert said that it would depend on the group, which in our scenario was a group of friends, and they probably would not have any problems with it. But in public spaces, like board gaming clubs, it could potentially be a bit awkward, due to the way you look wearing them.

When we asked the experts regarding the emotional aspects of using the smartphone, they did not completely understand what we meant. We gave them an example of the social stigma regarding the use of AR in *Pokémon GO* described in section 2.2, to give them some insight towards emotional aspects of AR usage. Further we extended the question to the social acceptance of mobile usage during face to face social experiences. All of the experts agreed on not seeing any major issues regarding that aspect. The explanations given for that response were mostly that all of the players would be in context and participate to the same degree, as well as mobile phones being to some extent part of most activities in many people's lives. Only one of the experts mentioned that depending on the context in which the game is played in, e.g. in public spaces where strangers could be watching, players could potentially feel emotionally uncomfortable.

Do You Think that the AR Feature Takes Away the Feeling of Playing a Game Together with Other Players?

Three out of the five experts agreed that the AR usage would not diminish the feeling of playing a game with other people, all saying that there would still be a lot of verbal communication involved, with only one of them adding that some extra encouragement for this verbal communication to take place might be needed. "Bill" and "Hans" both said that with some changes the AR usage could potentially even improve the experience in that aspect. Suggestions for those changes were creating more tense scenarios to provoke strong emotional reactions or creating more interaction between the players in AR, competitive or collaborative. While several experts said that a hindrance to creating a common experience would be that the players all had different screens and thereby saw different things, one expert pointed out that having separate screens could be used to give secret information to players and let them execute certain actions secretly, which could add another layer to the social interactions, e.g. through bluffing.

Other experts said that using the phone would take away from the experience of interacting face-to-face. "Kalle" and "Johan" were both of the opinion that headwear could solve that issue, as they would enable the players to see the other players

as well as the AR content without having to shift between modes. As technology improves and headwear becomes more affordable, headwear could become an interesting alternative to look into for future research.

What Do You Think Would Be the Largest Motivational Factors for Players to Start Playing the Game and Wanting to Continue Playing the Game? When asked about what aspect of the game would be a decisive factor for people to start playing Thieves: Wanted, most of the experts agreed that the prospect of a MAR board game could raise peoples' interests and make them at least want to try it, as it is a relatively unique and novel concept. However, expert "Bill" disagreed with that statement, saying the AR feature would not be a unique selling point and could instead deter people from trying the game as it would add complexity. AR would only work as a selling point if it would be made known, that it increased the value of the game in some way, either by providing a truly unique experience or by adding replay value. Expert "Johan" made a similar statement, saying if the AR added value to the experience it could get many people interest by word of mouth and potentially be a long term motivator to play the game. Another aspect brought up by expert "Kalle" was that the game's rule set was of relatively low complexity, which would make the game easy to pick up.

When asked about long-term motivational factors, which would make the players want to extend their play sessions or pick up the game another time, all of the experts mentioned some aspects of the social dynamics to be determining factor. While expert "Frank" highlighted specifically the more competitive elements, expert "Johan" named the more cooperative aspects of the game. The other three experts all stated the social dynamics resulting of the mixture of collaboration and competition to be what would make players want to continue playing. When asked to specify that all of the experts would highlight different aspects. However, all of the answers would allude to the many options the players had, which could take the game in different directions at any time, allowing for a multitude of different social dynamics to play out and potentially create unique gameplay experiences.

While there is not a complete consensus among the experts regarding the AR component making the game more attractive for a first time play, they seem to agree that if the AR component provided a unique and enjoyable gameplay experience, which is impossible to replicate without AR, it would definitely be factor which would make people want to play the game. However, in the case of the prototype of Thieves: Wanted, which was the subject of the evaluation, the social dynamics enabled by the more board game typical elements of the game, were the more engaging ones during gameplay.

Which Aspects of the Game Would Make a Player Want to Stop Playing the Game? When asked about which aspects of the game could make players want to quit the game, experts "Hans" and "Frank" brought up two issues discussed before. These issues were regarding the physical comfort while using the MAR app, as well as the inaccuracy when navigating in the app. These remarks, while not bringing up new discussion points, highlight that these issues are not just minor inconveniences, but are to be taken seriously as problems that could make a player want to quit a

play session. Expert "Bill" brought up the whole experience of the break-in missions as a whole being disappointing, as they did not feel exciting and could get repetitive. We would argue that describing the Break-in missions as disappointing shows that the prospect of MAR piques a player's interest, but also raise expectations that may not be met.

The experts "Hans" and "Johan" also mentioned more technical issues regarding mobile phone usages, addressing phones heating up and the battery drainage as concerns for people potentially having a bad experience and rather wanting or potentially being forced to stop a play session early. This shows that, while mobile phones may be an appealing platform for developers due to their accessibility, they also have weaknesses, most prominently the wide range of phones with varying hardware capabilities and running different OS variations, which makes it harder to optimize apps. This can lead to potential players feeling excluded from the experience due to having a less capable device. However, when discussing alternatives to mobile devices, expert "Johan" brought up that when using AR head-wear some way of interacting with the virtual content is necessary, which also has the potential to be annoying depending on the solution.

Some experts also stated some of the more board game typical and social dynamics related features to have the potential to result in demotivating and negative experiences. Expert "Frank" for instance, mentioned that spending an extended period in jail could make players lose interest in the game, as players in jail would have too little agency. Experts "Johan" and "Kalle" both named the exiling of players to have large potential for negative experiences. Both said that for the group to be able to single out a player and target the player as a potentially perceived victim could lead to a frustrating experience for that player. "Johan" as well as "Kalle" also added, that this would of course be dependant on how the group would handle the situation.

Expert "Bill" also brought up the exiling of players, but contrary to "Johan" and "Kalle" they mentioned that while seemingly worrying at first they actually see a lot of potential in putting single players in special roles. If this special role would open up options not available to the grouped players or put them in temporary situations where they have more power than the group, it could create interesting social dynamics. These answers show that, while all experts seemed to agree that the social dynamics were the more engaging factors when compared to the AR component, the social dynamics also have the potential to be demotivating if for some reason a player would feel excluded from the social experience. Especially in the case of the jail some experts said, that using the AR component could be an interesting way of giving the players more agency and keep them interested in the game. We would think that an expanded use of the mobile app, could also have the potential to improve the role of exiled players, as the individual screens could be used to present information exclusively to exiled players.

Do You Think AR Is Unnecessary for the Game Flow? We had a lot of contradicting answers for this question by the experts. For instance, Expert "Bill" said that in its current form it is certainly unnecessary. Meanwhile Expert "Hans" said it was part of the identity of the game. Expert "Kalle" gave an interesting

insight when they called it a breather, from the "regular" board game mechanics. Other feedback we received regarding the AR parts feeling like a gimmick was, that actions in the physical game, did not affect the state of the AR application. When designing the game, we were constantly questioning how much the board game state would affect the game state of the AR application. In the end we decided that it would not affect it at all. Something, in hindsight we possibly should have investigated more.

6.5.7 Developer Evaluations

Due to the experts not being able to experience the physical board game, we further tested the game in regards to physical aspects by ourselves. In our opinion this further evaluation was required, as some of the aspects of the game were not discussed in great detail by the experts. We think that this is due to the experience in Tabletop Simulator being severely different to the physical board game in some aspects. The observations discussed here emerged from our own testings and are therefore to be interpreted with caution, as they may include personal bias.

Some of the issues identified by the experts, we did not perceive as significant during our own evaluations. One of these issues was stated by Expert "Hans" as the game best being played from one position and a top down angle. During our evaluation we experienced that we were moving more than what was described by many of the experts. Often changing the distance to the marker, occasionally going very close to collect objects and then going further away to get a better overview of the map. While we did notice that the gameplay could sometimes feel fiddly and the UI would occasionally get in the way, we think that the previously described behaviour of more movement made these issues less prevalent during our evaluations.

We found that there was an annoyance with using the phone during every round of the game. This was due to the amount of steps needed to use the phone. First picking it up, entering the pin code, opening the game app, playing the game, and finally putting it down again. Our own conclusions on that matter are similar to the conclusions of expert "Kalle", who thought it might be better to have them further apart.

7

Results

In this chapter we present the results of our thesis. These results include the design considerations, which were formulated based on our findings to answer the research question, as well as the MAR board game prototype Thieves: Wanted, which was developed in the process of this research.

7.1 Thieves: Wanted (A Mobile Augmented Reality Board Game)

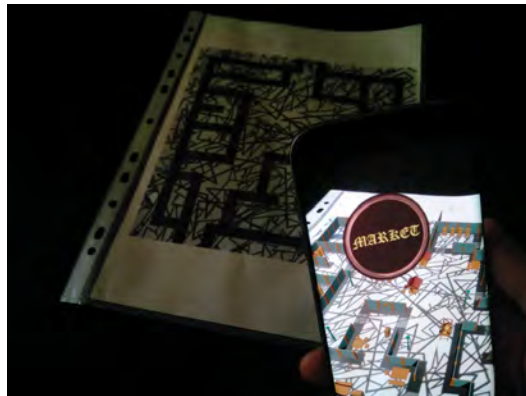
The first result we present for this thesis is the game we made, Thieves: Wanted. Which is a MAR board game, where each player takes on the role of a thief. The players will need to cooperate towards common goals, but there can only be one winner.

The game consists of several rounds. Each round consists of two phases, which we call: Night phase, and Day phase. The actions the player can take depend on the phase. The game begins with the night phase. At the beginning of the night phase an event card is drawn. When the night phase has ended the day phase begins.

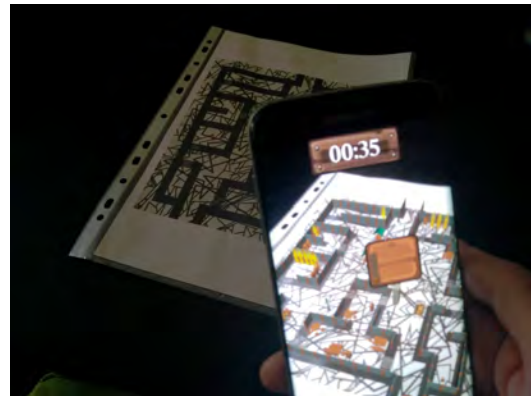
The game consists of four levels (AR markers), four gold pouches, four wanted level markers, prosperity level marker, event cards, objective cards, slum item cards, market item cards, harbour item cards, a fencing die, four player dice and a bunch of gold markers.

The game has several end conditions resulting in one of two states, successful or unsuccessful. There is one condition to reach the successful end game state. This condition is fulfilled when the maximum prosperity level is reached. In case this end game condition is reached, the player who has amassed the most amount of gold wins the game. There are several ways to reach an unsuccessful end state. First of all, if all of the event cards have run out, the game ends in an unsuccessful way. If there is nothing more to steal, meaning there are no item cards available, the game ends in an unsuccessful way. Further there are events, that can end the game in an unsuccessful way. If the game ends in an unsuccessful way the player with the lowest wanted level wins the game, the player who will spend the least amount of time in jail.

Break-in Missions The player begins by choosing the level where they wish to break in, doing so by clicking on the name of the level seen in figure 7.1a. When the Break-in mission starts, a timer at the top of the interface appears as seen in figure 7.1b. The player collects loot by clicking on shiny objects, and waits for their



(a) Starting a break-in mission.



(b) View of a break-in mission in MAR.

Figure 7.1: The Thieves: Wanted MAR application in use.

player avatar to reach that object. Collecting loot increases a noise bar by a fixed amount. The player should try to collect as much loot as possible and escape the level before the timer runs out. Should the player fail to escape the level in time or the noise bar fill up completely their wanted level increases. Afterwards they can attempt a secondary escape. For the secondary escape attempt you need to roll a six sided die. The number you roll needs to be greater than the amount of loot you try to take from the area. Before you roll the die, you can draw the loot cards from the corresponding loot deck, look at the cards and decide to discard any number of them, making the escape easier. If this escape attempt also fails you go to jail.

Jail At the start of each round the wanted level of players in jail is decreased by one. If they start a round in jail with a wanted level of 0 they are released from jail. If a player is in jail, during the night phase, the player can try to escape from jail by rolling two dice. If the result from both dice are equal the player immediately escape from jail.

Fencing You can sell the items you stole to a fence. At the beginning of the day phase a fence die is rolled. This die determines how much the stolen items are sold for. This is a risk-reward situation, because ideally you want to sell the items for its maximum value, meaning you might want to wait a few rounds before you sell. However, holding onto cards can pose a risk. For instance if you go to jail, the player will lose all of the cards on hand, meanwhile their gold is untouched.

Steal From Other Players A player can steal cards from other players during the day phase. To do this you roll a six sided die, the player you wish to steal from also needs to roll a six sided die. If the player who initiated the theft has a higher die roll than the other player, the player blindly picks on the other player's cards. The other player might have a bear trap, which is an item that prevents theft. That item can be used if the player do not wish to give away a card.



(a) Event card. (b) Objective card. (c) Loot card.

Figure 7.2: Card types.

Snitching If a player is in jail, the player can choose to snitch on another player. This decreases the player in jail's wanted level by one and increases the wanted level of the other player by one. A player can not snitch on another player already in jail.

Cards There are three types of cards in the game: event cards, objective cards, and loot cards, examples of these cards can be seen in figure 7.2. A full table of the event cards can be seen in appendix A.5, as well as all of the objective cards can be seen in appendix A.4. All of the slum cards can be seen in appendix A.1, all of the market cards can be seen in appendix A.2, and finally all of the harbour cards can be seen in appendix A.3.

Main Menu We needed to make a main menu for the game, to allow for players to connect and login. As well as according to the Vuforia [61] specification you should not enable AR immediately.

The first menu screen the player sees the login screen, subfigure 7.3a. Here the player just enters the visual name they want to be associated with.

In the second the screen the player can choose between hosting a game, or joining a game.

Levels The final game includes four levels: Slum, Market, Black Market, and Harbour.

Each of the level markers has an individual design showing the outlines of the level as seen in figure 7.4. In AR these markers are augmented with virtual walls and other obstacles, as well as possible loot locations. The actual loot locations change every Break-In mission. Particle effects are used to highlight these actual locations. Slum is the first level in the game and is unlocked when first starting the game, see figure 7.5a. Market is the second level in game and is unlocked at level two of prosperity, see figure 7.5b. At prosperity level three the Black Market level is unlocked, see figure 7.5c. The last level to be unlocked is the Harbour level at prosperity level four, see figure 7.5d.



(a) Iteration 1: Just the level outlines. (b) Iteration 2: Added generated marker. (c) Iteration 3: Added further details manually.



(d) Iteration 2: Added generated marker. (e) Iteration 3: Added further details manually.

Figure 7.3: Main menu.

7.2 Considerations

In the following we state and explain the different considerations we were able to formulate from our findings, which should help game designers to create engaging MAR board game experiences.

Consider If AR Is Necessary for the Game Design Our findings showed, that developing AR content should be avoided if it is not necessary for the designed game.

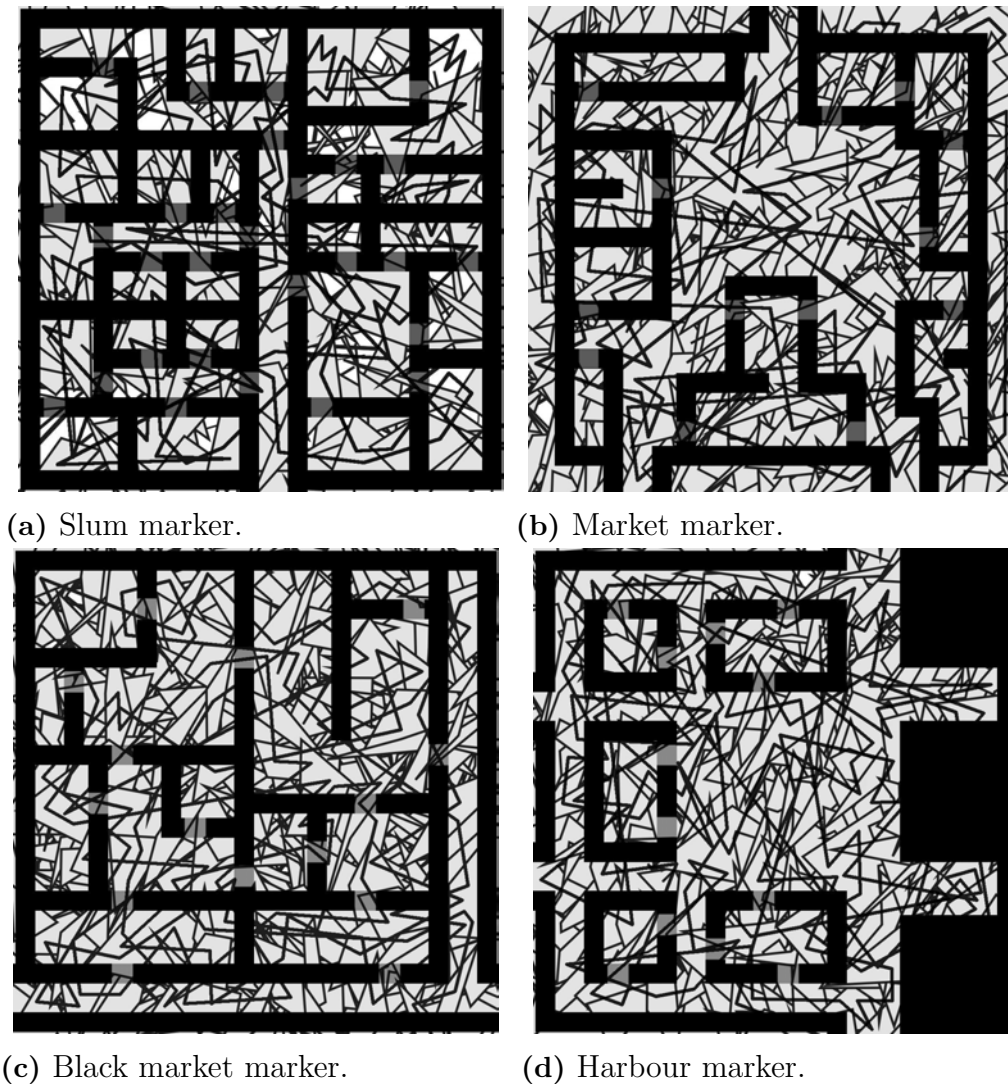


Figure 7.4: Markers for the levels.

In the case of Thieves: Wanted all of experts asked to evaluate the prototype stated, that the AR app could have been replaced with just a digit augmentation. Many of the issues especially regarding physical comfort can be traced back to the players having to position the camera, which arises because of the AR implementation.

If a game design works without AR, it is probably best not to have AR, as it also increases the workload of development. During the development of Thieves: Wanted, most issues during the implementation of the MAR app stem from AR development, e.g. when implementing the path finding. Further, developing the MAR app introduced steps, which would have been completely absent without AR, e.g. designing and optimizing the tracking markers.

Incorporating AR may also complicate the resulting game and thereby worsening instead of improving the experience.

Consider the Length of MAR Usage Designers should consider how long the MAR app is used without interruption, as the industry is concerned with the

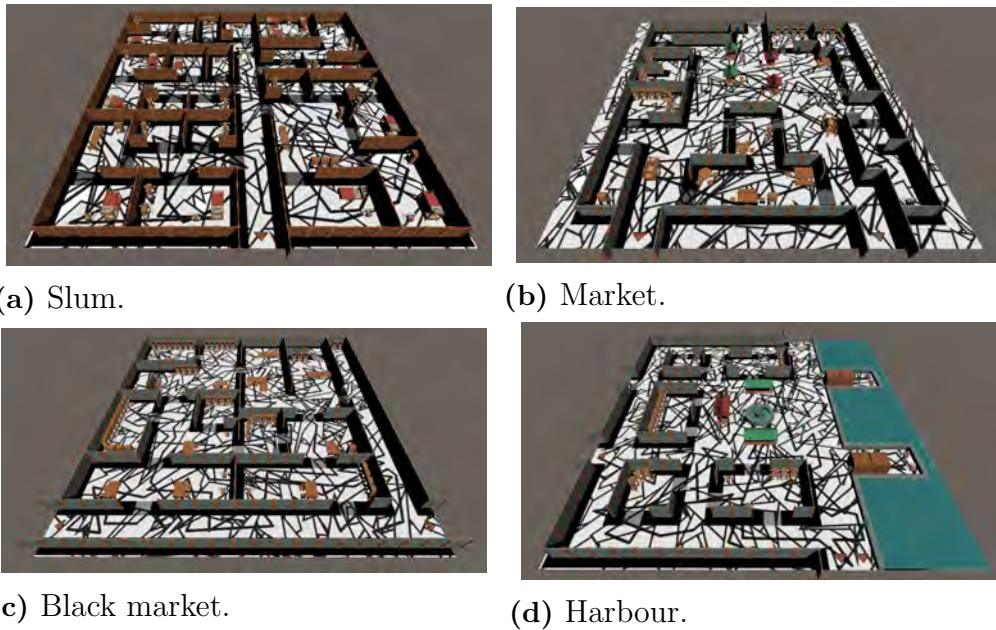


Figure 7.5: The levels

ergonomics with lengthy mobile phone usage in MAR. Long mobile phone usage may be straining on the hands and arms, which could distract the player from the gameplay.

Further, designing breaks from the usage or allowing the players to take breaks may let the players use their time to focus on other aspects of the board game experience, e.g. interacting with other players, as some of the experts were concerned with the MAR app getting in the way of social interactions.

When only little time is spent using the MAR app, this can help to make the MAR segments feel special, according to one of the experts. However, one can also argue, that if it is only used for a short time, that AR might be unnecessary for the game.

Running MAR apps can also be demanding for some devices, as it was the case in tests of *Thieves: Wanted*, during which some phones heated up while the MAR app was in use. Having breaks in the usage can prevent phones from heating up. Here the total use time should also be considered, as power consumption and battery lifetime set a limit for that.

Consider Players Physical Positioning The players physical positioning while using the MAR app is relevant to the time a player may use it until they feel strained. For example, one of the experts evaluating *Thieves: Wanted* described, that they felt like they had to stand up and lean over the table to properly play the game, which would be an uncomfortable position.

Considerations would be if players are able to rest their arms, if they have to stand up or possibly move in the physical space. If the game requires movement, designer should also consider the range of movement and the safety of the players, which is also a topic referred to in the AR Design Guidelines by Google.

Consider Physical Actions When designing MAR board games, the physical actions a player needs to take while playing are to be considered. For *Thieves: Wanted* most experts thought, that, while the digital augmentation was important for the game experience, the AR felt unnecessary. One of the reasons for this was stated by some of the experts to be, that camera movement was not required, in fact it would have been easier to play the game from a static angle.

An idea that was brought up by an expert, which in their opinion could have improved the way MAR was incorporated into the game, was to combine multiple markers to create paths and impact the levels in AR. From this it could be concluded, that manipulating objects to change the digital representation in AR could be another physical action, in which players could engage to interact with the MAR system.

Engaging the player in some sort of physical action may help to create experiences that are more unique when compared to purely physical or digitally augmented board games. These actions could for instance be the player moving the camera or manipulating physical objects in front of them.

Consider Other Motivators/Selling Points As MAR board games are rather novel, players may initially be intrigued by the prospect of playing it, as stated by the experts, who evaluated *Thieves: Wanted*. However, our findings also show that this interest due to the novelty can wear off quickly even within the first play session. Designers may want to consider other motivators to engage players for longer periods, besides the aspect of MAR. In the case of *Thieves: Wanted* most of the experts stated, that over longer time the cooperation, competition, or the blend of the two and the resulting social dynamics would be the most motivating aspects of the game.

Consider Obscuring Visuals AR combines real world information with virtual information. As players may likely require the information of both spaces simultaneously, it should be considered that objects in one space do not obscure relevant information of the other space.

In the case of *Thieves: Wanted* some of the experts mentioned they had troubles navigating the avatar in the app the way they wanted to. This was in part due to virtual objects obscuring the parts of the marker and other virtual objects.

Other factors, which need to be considered regarding obscuring visuals, are also the shifting of objects due to the non-static camera and the varying sizes of smartphone screens.

Consider Inaccuracy of Touch Inputs When designing interfaces for touch screen inputs, designers always have to consider the inaccuracy of fingers compared to e.g. a mouse cursor. Our research suggests, that this is especially important for MAR apps. Interactive objects are here typically anchored in the real-world and may therefore change screen space positions unintentionally due to the non-static camera. This can lead to failed inputs, which may increase if players have shaky hands or get exhausted, and ultimately frustration, which may cause players to disengage.

One of the experts stated, that while using the MAR app, they struggled to make the inputs they wanted, as objects would obscure narrow clicking spaces as the camera angle would change. Further they highlighted, that they had shaky hands, which made executing the intended inputs even harder.

Consider How Information Is Presented Graphical user interfaces are often used to present information to players in digital games. As the Google guidelines suggest, these should be avoided in AR.

Our findings suggest that placing the UI in world space, can lead to other information being obscured. As pointed out by most of the experts, the world space UI in *Thieves: Wanted* would restrict the player's view of the scene, which would make them feel like they are missing relevant information or prevent them from executing the correct actions. Some of the experts even said, that in their opinion a screen space UI would have been better in the case of *Thieves: Wanted*.

Designers may want to consider how they want to present information to the players. If using a UI to do so, they may want to consider in which space the UI should be, and if this representation could be perceived as an impediment in some way or immersion breaking. Further designers may want to consider other ways of communicating information, e.g. audio, or some form of diegetic interface.

Consider the Synchronization of Game States Designers of MAR board games, may want to consider to what degree they want the game states of the physical board game and the MAR app to be synchronized. Here it is not a question of synchronization or no synchronization, as it also possible to only synchronize certain aspects or a fraction of the game state.

A more synchronized game state may enable more gameplay options in AR and make the two mediums feel less separate, leading to a more homogeneous experience. Some of the experts, who evaluated *Thieves: Wanted*, criticised, that the AR sections of the game experience always played the same, and said, that they could get repetitive over time. This was at least partially due to the two game states having close to no synchronization, as the state of the MAR app was never affected by changes in the board game, other than unlocking new areas. An idea to increase the amount of synchronization in *Thieves: Wanted*, brought up by one of the experts, was to e.g. scan item cards from the board game to have them available in the MAR app.

Less synchronization of game states may make the game feel disconnected and be disruptive to the experience. However, the process of synchronizing the game states may require actions, which can possibly be perceived as chores, but may also be perceived as unwanted excise. There are potentially ways to automate the synchronization process to minimize the excise. However, this would remove control over the game state from the players, in which case a synchronized game state may interfere with players enacting house rules, which may be a desired option.

Consider Player-Player Interactions With smartphones present as an additional medium, how players interact with other players may require special consideration. They can be given options to interact in the virtual space. However, some players may think that virtual communication takes away from the social experience

of playing a board game, as it was a concern voiced by one of the experts. Designers may want to consider encouraging face-to-face interactions to keep the smartphones from taking too much attention.

One of the experts also mentioned the players having separate screens to view the scene would be a hindrance to creating a common game experience. However, another expert mentioned making use of the separate screens to allow showing information and executing actions secretly, as an example of adding a new layer to the social dynamics. Another way for players to interact in AR would be that one player manipulates physical space to change the virtual content for other players.

Consider Limitations of the Hardware Different devices have different strengths and weaknesses. Especially in the case of MAR the wide range of available hardware can be seen as a limitation, as smartphones evolve rapidly and therefore devices quickly become outdated. The wide range of devices also makes it harder to optimize the MAR app. Optimizing the app for relatively outdated hardware may allow many players to play the game without issues, but it may also restrict the developers and designers. On the other hand, optimizing the app for the latest hardware or not optimizing the app at all, may lead to players having issues running the app, or experiencing concerning hardware behaviour, like e.g. the device heating up. Some of the experts experienced their device heating up when testing the MAR app to *Thieves: Wanted*, and stated, that an issue like that could ruin the game experience for a whole group, even if only one of the players experiences them directly.

Another limitation can be, that every player looks at a different screen, which can disrupt creating a shared experience. However, some of the limitations can also be taken as strengths, e.g. the wide range of devices also means that many people have access to those devices and the separate screens could be used to share secret information.

Consider How to Introduce Players to Interactions in AR The use of MAR enables many ways for players to interact with the system and one another. Many players may be unfamiliar with those ways of interacting, as MAR especially in board games is still relatively new. Designers should consider how to introduce new players to those interactions. It could be desirable to strongly guide the players early on to make it easier to pick up the game. However, it could also be argued that figuring out the different ways of interacting with the system is part of the challenge of mastering the game.

One of the experts stated, that especially for people who are unfamiliar with MAR, having it added to a game might be overwhelming in the beginning. Therefore making the initial steps to playing in MAR as easy as possible may be desired. Further, this consideration may change overtime, as AR might become more common and more people gain experience using MAR systems.

Consider AR Adding Complexity When designing an AR game, one should be aware that while opening many possibilities, AR also adds complexity to the resulting game. This added complexity not only manifests in terms of interacting

with the game, but also steps outside of the gameplay, like installing the app and potentially having to deal with other technical issues that may arise.

As one of the experts stated, having MAR involved with a board game may actually be scaring off some players as opposed to raising interest. According to the expert, this could be the case as some players may not be confident in their technical knowledge and think the AR would be too complex for them to understand and could create problems when setting up a play session.

This additional complexity and dealing with potential problems can be perceived as excise, so designers may want to consider ways of handling these tasks to minimize this excise.

8

Discussion

In this chapter we will discuss our results, and our process. Doing so we reflect on the limitations and generalizability of the research, and how decisions in the execution might have affect the results.

8.1 Execution Discussion and Planning Changes

Due to the corona pandemic things did not go exactly to plan. The two most evident changes were that the originally planned user tests could not be conducted in an ethical way. Secondly we could not properly evaluate our physical board game prototype and we instead had to rely on Tabletop Simulator. Apart from that our execution did not change that much. There were technical difficulties which we did not foresee during the planning of the application, however, these thing were to be expected, and we were not working on application for longer than originally planned. First we designed three concepts of games. The design of these concepts originated from the background work we did in this thesis, as well as other board games for inspiration. Our goal here was not to create a unique board game experience, but rather a prototype to be used as a foundation to evaluate MAR board games in general. In the first concept we failed to come up with a good way of combining MAR with the board game. Because of this, we tried to primarily focus on creating a functioning board game without MAR when developing our second concept. This was also due to us feeling that physical board games were faster to prototype and iterate upon. After several iterations of the second concept, so much of the game had changed, as well as MAR having been added into the mix, we decided to call it concept three. This was further iterated upon by testing the game internally and making changes according to issues and new ideas that came up during and after the tests.

The process of initially ignoring the MAR component, may have lead to it not being as integrated with the rest of the game as we initially planned it to be, as also pointed out by the experts. This might have changed the data we have received from the experts, for better or worse.

As we initially planned to conduct user tests, our aim was to develop a user friendly prototype. We did not change the aim of the development even after we decided it was not ethically possible to conduct the user tests. We felt this was a mistake, since the experts did not care as much about the playability of the game and were more interested in the concept. The game itself was more or less used as an initiator to start conversations with the experts regarding MAR board games. In hindsight,

we felt that we should have not spent as much time on the development of the game, and rather spend the time on refining the concept, gather more data from the experts, and possible even invite more experts.

Another approach could have been to develop multiple concepts to a point where they could have been evaluated instead of trying to end up with one high-fidelity prototype. This could potentially have sparked a more varied conversation with the experts.

For the expert evaluation we decided to give the experts some questions to keep in mind during the analysis, which we planned to discuss during the interviews. This was done to let the experts know what information to look for when analysing the game. If we had not done that the answers would probably have been different, and some of the questions may have come out of left field for the experts. We think that in that case the answers would have been less insightful. However, if it had been a proper user test as initially intended we would not have done so, as in that case the intention would have been to learn from user behaviour and issues that might have come up during play and not from the users analysing certain aspects of the prototype.

After the interviews with the experts we spend a lot of time transcribing the audio recordings. Relying only on audio recordings without taking any notes for the interview was something in hindsight we felt was a mistake. We believe that a combination of notes along with audio recordings as backup, would have been a better approach.

8.2 Limitations

The list of considerations that we gather is of course not complete, nor can we confirm if each of the considerations are conclusive. Since the research question is a wicked problem however, there is not a single right answer for the question. Rather, better or worse answers for the question. In our processes we have tried to be as unbiased as possible, but of course, within a research subject like this it is hard to completely avoid any bias.

There are several ways, in which bias can have been introduced into the project. A few of them we have identified. First, the expert selection, we were in charge of the expert selection, here we might not have selected the best representative experts. Second, the experts themselves have personal opinions and may have introduced bias, as for instance Expert "Bill" seemed not to like games that make use of new technologies without taking full advantage of their capabilities in its gameplay design. This for instance was an opinion we did not feel was shared with the other experts. Further, personal bias might have contaminated our process of evaluating the interviews we made with the experts.

To reduce the bias we could have had user tests, although regular users would most likely not been able to add as much insight as the experts. Having user tests with at least around twenty people could have added some statistical significance to the qualitative study, which in turn could have led to less bias.

Further, the results of the research is limited to the design of our game. Even though we talked outside the scope of the game with the experts, they still had the game

we created as a reference point, when discussing MAR board games.

8.3 Generalizability

Due to MAR board games being a relatively new concept with not a lot of prior research, our research is not trying to solve any concrete problem, rather highlight things that need to be considered concerning developing MAR board games. However, some of our experts were contradicting each other. But again, our results are a set of considerations, and not strict rules which are to be applied. Individual considerations could be investigated further.

There are certain details within the interviews that are specific to our game, for instance several of the experts were talking about the exiling mechanic, something that not all MAR board games will have. Of course, we are sure our research did not reveal everything that needs to be considered when developing MAR board games, and we would not regard our list of considerations to be complete.

As AR technology is rapidly evolving, AR headware might become more common. This might make these considerations outdated in the future. Further MAR improvements, such as better technology for markers and markerless technology, might remove some consideration or extend the list provided in the conclusion.

8.4 Future Work

For future work, regular user tests could be conducted, as we were unable to do them in this study. It would be interesting, and worth analysing how these results would differ. As well as having more of a quantitative data set of statistic significance for comparison. Further a deeper look into some of the consideration could be worthwhile, to further expand on the consideration, as for important details that might have been missed in this study. Something we did not cover in this study, is what to consider when developing for certain kinds of handicaps, for instance color blindness.

As AR technology is rapidly evolving, and with the *Tilt Five: Holographic Game System* [60], it may be worth looking at considerations regarding headwear in comparison to smartphones as they may differ. Also to look for commonalities, which can be worthwhile in regards to cross platform development.

9

Conclusion

Because of the corona crisis we could not do the user tests as planned, which we think affected the results. As we would like to have more quantifiable metrics to derive from when answering the research questions. However, the experts gave us useful insight, that we might not have gotten from a regular user test.

This master thesis was set out to answer the following research question:

What should be considered when designing a board game, which utilizes mobile augmented reality, with regards to player engagement?

We answered the research question by providing a total of 13 considerations, as can be seen summarized in a bullet list below. The full list of considerations with descriptions can be seen in section 7.2. Since the research questions is a wicked problem, the list is of course not complete. Personal bias might have had an effect on the considerations mentioned, along with the experts that we chose for the evaluations, and finally the game that we made. However, we still think these considerations are valuable for game designer wanting to design MAR board games.

- Consider If AR Is Necessary for the Game Design
- Consider the Length of MAR Usage
- Consider Players Physical Positioning
- Consider Physical Actions
- Consider Other Motivators/Selling Points
- Consider Obscuring Visuals
- Consider Inaccuracy of Touch Inputs
- Consider How Information Is Presented
- Consider the Synchronization of Game States
- Consider Player-Player Interactions
- Consider Limitations of the Hardware
- Consider How to Introduce Players to Interactions in AR
- Consider AR Adding Complexity

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A

Appendix

Card Name	Description	Number Of Cards
No Value	An item with no sell value.	8
1 Gold	Use: <i>Gain one gold.</i>	3
Old Shoe	Course Value 1 - 3 1 4 - 5 2 6 3	3
Bear Trap	Course Value 1 - 3 1 4 - 5 2 6 3 Use: <i>Prevents a player from stealing your cards. Can be used after both players have rolled their dices.</i>	3
Incriminating Documents	Course Value 1 - 3 1 4 - 5 3 6 5 Use: <i>Can be used to decrease your wanted level by 1.</i>	3

Table A.1: Slum cards.

Card Name	Description	Number Of Cards
No Value	An item with no sell value.	7
1 Gold	Use: <i>Gain one gold.</i>	2
3 Gold	Use: <i>Gain three gold.</i>	2
Old Shoe	Course Value 1 - 3 1 4 - 5 2 6 3	2
Love Potion	Course Value 1 - 3 1 4 - 5 3 6 5	2
Weapon	Course Value 1 - 3 1 4 - 5 2 6 3	1
Old Fish	Course Value 1 - 3 1 4 - 5 2 6 3 Use: <i>Prevents a player from stealing your cards. Can be used after both players have rolled their dices.</i>	2
Invisibility Potion	Course Value 1 - 3 2 4 - 5 4 6 6 Use: <i>Lets you escape from a failed break-in mission.</i>	2

Table A.2: Market cards.

Card Name	Description	Number Of Cards
No Value	An item with no sell value.	5
1 Gold	Use: <i>Gain one gold.</i>	2
Grog	Course Value 1 - 3 1 4 - 5 2 6 3	2
Silk Cloth	Course Value 1 - 3 2 4 - 5 4 6 6	2
Bag of Salt	Course Value 1 - 3 1 4 - 5 3 6 5	2
Exotic Herbs	Course Value 1 - 3 1 4 - 5 3 6 5	3
Invisibility Potion	Course Value 1 - 3 2 4 - 5 4 6 6 Use: <i>Lets you escape from a failed break-in mission.</i>	1
Old Fish	Course Value 1 - 3 1 4 - 5 2 6 3 Use: <i>Prevents a player from stealing your cards. Can be used after both players have rolled their dices.</i>	3

Table A.3: Harbour cards.

Card Name	Objective	Reward	Number Of Cards
Behind Bars	Spend time in jail.	4 Gold.	4
Black Friday Offer	Steal at least one item from the black market.	2 Gold	4
Bootsy	Steal an old shoe.	2 Gold	4
Dead or Alive	Have your wanted level increased.	2 Gold	4
Free Market	Steal at least three items from the market.	2 Gold	4
Freebooter	Steal at least one item from the Harbour.	2 Gold	4
Gold Rush	Steal a three gold items.	2 Gold	4
Heart of Gold	Donate a 3 Gold to the sanctuary bank.	2 Gold	4
Hoarder	Have a full inventory.	4 Gold	4
Master Thief	Have a full inventory.	4 Gold	4
Sneak 100	Make an successful escape.	1 Gold	4
Snitches Get Riches	Snitch on another player	5 Gold	4
What Honor?	Steal an item from another player.	2 Gold	4
Welcome More	Exile another player.	5 Gold	4

Table A.4: Object Cards

Card Name	Description	Number of Cards
A Dull Evening	Nothing really happens this evening, the players can each roll a die, just for fun.	4
Debt Collecting	The guild collecting their debts. Place gold in the sanctuary bank depending on the guild's prosperity level. Prosperity Level Payment in Gold 1 1 · Number of Players 2 2 · Number of Players 3 4 · Number of Players 4 6 · Number of Players	4
Raid!	The town guards have raided our sanctuary. They need to be paid off: Prosperity Level Payment in Gold 1 1 · Number of Players 2 2 · Number of Players 3 4 · Number of Players 4 6 · Number of Players <i>If you fail to pay off the guards it will result in an unsuccessful game over.</i>	4
Raid!	The town guards have raided our sanctuary. All stolen items are returned to the discard piles of each respective location.	4
The Brightest Night	Every player must discard one stolen item after an escape: successful, or failed.	4
The Darkest Night	Every player can draw one extra loot card after a successful break in escape.	4
The Diversion	Every non-exiled player decreases their wanted level by 1.	4
The Diversion	Every non-exiled player decreases their wanted level by 2.	4
The Snitch	One of the player has been snitching to the police. Every player rolls one six sided die. Increase your wanted level: Prosperity Level Payment in Gold 1 - 3 2 4 - 5 1 6 0	4

Table A.5: Event Cards.

B

Appendix

Questions

- Do you think player would feel uncomfortable using the smartphone? (physically or emotionally)
- Do you think that the AR features takes away the feeling of playing a game together with other players?
- What do you think would be the largest motivational factors for players to start playing the game and wanting to continue to play the game?
- Which aspects of the game would make a player want to stop playing?
- Do you think AR is unnecessary for the game flow?

Figure B.1: The questions as sent to the experts.

We will record the audio of the interview following the analysis. We will destroy the recording when the research is published. Only us and our supervisor will have access to the recording.

You can quit the analysis and decide not to be part of the research at any time.

We want to emphasize, that this is not a formal test. This is an expert review.

When publishing data gathered from this evaluation, we will make sure not to include any information, that can be traced back to you.

Figure B.2: The information about the recordings as sent to the experts.

Thieves: Wanted

You play as a member of a gang of thieves hidden in a sanctuary to amass your wealth. During night time the gang goes out and breaks in into the different districts of the town. During the day, the thieves do their bookkeeping - so to say, fencing loot, or stealing loot from the other thieves. The goal is to cooperatively create a thieving empire, but only one of thief can be the emperor.

The Round

- Begin a new round by drawing an event card.
- The round consist of two phases (Night and Day).
- You should always have one objective card on hand (Draw the first one at the start of the game and replace with a new objective after completion)

Night Phase

- During the night phase the player can go on a break-in mission, using the app on their phone.
- Players can also stay in hiding during the night phase modifying their wanted level by -1.
- Failed escape:
 - Draw the cards that you got from the escape.
 - After looking at the cards you can choose to discard as many as you want.
 - Roll a D6, if the cards on hand is less than the dice roll, the player goes to jail (see Jail).
 - If the player does not go to jail increase the wanted level of the player by the amount of cards on hand.

Break-In Mission

- Select which area to break-in to by pointing the camera towards the corresponding tracking target and tap the button.
- Collect loot and escape before the timer reaches 0.
- Collect loot by tapping highlighted objects.
- Collecting loot creates noise.
- Escape the area by tapping on the exit fields, which are marked by arrows.
- If you escape the area before the timer reaches 0 and the noise meter is not full you succeed. Draw cards in the number of loot you collected from the corresponding loot deck.
- If you fail to escape before the timer reaches 0 or the noise meters is filled you fail to escape unnoticed. Increase your wanted level by the amount of loot you collected in the area. Make your secondary escape attempt.
- For the secondary escape attempt you need to roll a D6. The number you roll needs to be greater than the amount of loot you try to take from the area. Before you roll the

Figure B.3: Page 1 of the rules as sent to the experts.

die, you can draw the loot cards from the corresponding loot deck, look at the cards and decide to discard any number of them. If this escape attempt also fails you go to jail.

Day Phase

- At the beginning of the day phase roll a dice for the fence.
- Actions:
 - Change your objective. If there are no objectives left to draw, reshuffle the discarded and completed objectives.
 - Trade between players.
 - Sell items to fence.
 - Vote to exile players or take them back in.

Fence

- Roll the fence die (black die) at the start of the day phase.
- Sell items for the amount of gold specified on the card.
- Items sold at the fence are added to the loot deck of the Black Market area.

Jail

- At the beginning of you can roll 2D6. If both dice shows the same result you can immediately escape from jail.
- At the beginning of each round the wanted level is modified by -1. When the wanted level of the player is 0, the player is set free at the beginning of the next round.
- Players can snitch on one other player during each day phase. This modifies the players wanted level by -1 and increases the player the player snitch on by +1.

Prosperity Level

- | | |
|--------------------------|----------------------------|
| • Level 2 (Market) | 3 gold * number of players |
| • Level 3 (Black Market) | 4 gold * number of players |
| • Level 4 (Harbour) | 5 gold * number of players |
| • Level 5 | 7 gold * number of players |

End of the Game

- Prosperity Level 5 is reached. Winner is the player with the most gold.
- Event Cards run out. Winner is the player with the lowest wanted level.
- Failed to pay off a raid event. Winner is the player with the lowest wanted level.
- Running out of loot cards to draw (in all unlocked areas). Winner is the player with the lowest wanted level.

Figure B.4: Page 2 of the rules as sent to the experts.