A Design-Led Investigation of Augmented Reality

A Case of AR for Board Games

By Naman Thakar

Exegesis documentation and Appendices submitted
in fulfilment of the requirements for the degree
Doctor of Philosophy

School of Architecture and Design
RMIT University
Melbourne, Victoria, Australia.

7 January 2015

Supervisors
Dr. Flora D. Salim and Dr. Stefan Greuter
Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged; and ethics procedures and guidelines have been followed.

Naman Thakar
7 January 2015
Acknowledgements

I would like to thank my brother Nandan for all the support and encouragement, for the last 30 years. My wife Chini for carrying me through the last year of this PhD. Thank you Hiral and Reva, for all the support and love. This PhD has been guided by my supervisors, Flora Salim and Stefan Greuter, I thank you for all your inputs, suggestions and patience. Dr Campbell Aitken of Express Editing Writing and Research provided professional editing services in accordance with the Institute of Professional Editors’ Guidelines for editing research theses.

I would like to remember Emre Ozfetis and Helen Sky, you guys made the lab feel good. Andrew Burrow, for all the discussions that went everywhere. William Corbier Jr., it was great to work with you. Thanks all the support Dad. I love you Mom, look at me now!

I dedicate this PhD to my Ba, the kindest and most loving person in my life. You are always with me.
# Table of Contents

Declaration

Acknowledgements

Table of Contents

List of Figures

List of Tables

Abstract

## Chapter 1 Introduction

Overview

1.1 Augmented Reality

1.2 Significance of this Research

1.3 The Typical Scenario of a Board Game Session

1.4 Manuals, Tutorials, Learning from Players

1.5 New Player Problems

1.6 Methodology

1.7 Findings and Contribution

1.8 Chapter Summary

1.9 Exegesis Outline

## Chapter 2 Background and Related Work

Overview

2.1 Augmented Reality Definition and Examples

2.2 A Brief History of AR

2.3 Recent Trends in Augmented Reality

2.4 Related Work

2.4.1 AR in Assembly Processes and Industrial Maintenance

2.4.2 Spatial Augmented Reality

2.4.3 Learning Theories

2.4.4 AR and Board Games

2.5 Board Game Tutorials and their Limitations
List of Figures

Figure 1: The Design Process ........................................................................................................... 11
Figure 2: Boeing’s prototype wire bundle assembly application ................................................. 15
Figure 3: Ivan Sutherland’s Sword of Damocles (1968) ................................................................. 16
Figure 4: The Terminator’s Vision from the Movie Terminator 2: Judgement Day (1991) ........ 16
Figure 5: Ironman’s Heads-up-Display from the Iron Man Movies (2008, 2010, and 2013) .... 17
Figure 6: Heads-up Display (HUD) of a Fighter Jet ................................................................. 17
Figure 7: Crew Member of Avatar (2009) Explaining How SimulCam Works ......................... 18
Figure 8: Proposed View of an AR app by Earthmine ................................................................. 19
Figure 9: Google Founder Sergey Brin wearing Google Glass ..................................................... 19
Figure 10: Components of META’s Space Glasses ............................................................ 20
Figure 11: Milgram’s Virtuality Continuum .................................................................................. 21
Figure 12: Summary of Steps for Tracking Markers in ARToolkit (1999) .................................. 22
Figure 13: Google Trends Graph for “Augmented Reality” ...................................................... 24
Figure 14: Google Trends Graph for “Augmented Reality (blue)” and “Cloud Computing (red)” 25
Figure 15: Metaio’s AR Reference Manual for Audi cars ......................................................... 34
Figure 16: Official Catan Manual Pages 3 and 4 ................................................................. 36
Figure 17: Official Catan Manual Pages 4 and 5 ................................................................. 37
Figure 18: Official Catan Online Tutorial .................................................................................... 38
Figure 19: Official Catan Online Tutorial .................................................................................... 39
Figure 20: Official Catan Online Tutorial .................................................................................... 40
Figure 21: Official Catan Online Tutorial .................................................................................... 40
Figure 22: Prof Easy’s Catan Assistant on iPad – Welcome Screen ....................................... 42
Figure 23: Prof Easy’s Catan Assistant on iPad - 2 ................................................................. 42
Figure 24: How Activity Theory expands the scope of interaction design ......................... 51
Figure 25: Eurogames at The Royal Standard .............................................................................. 60
Figure 26: Ethnographic Observations on Board Game Flash Point ........................................ 62
Figure 27: Example record of a game session ............................................................................ 65
Figure 28: The First Generation Activity Theory Model: Vygotsky’s Model of Mediated Action 75
Figure 29: The Second Generation Activity System Model (Engeström, 1987) ....................... 76
Figure 30: Activity System for The Game .................................................................................. 78
Figure 31: Activity System for The New Player ......................................................................... 78
Figure 32: The Design Process for developing the AR Setup ..................................................... 85
Figure 33: Notebook drawings for ideas before first iteration (1) ............................................. 87
Figure 34: Notebook drawings for ideas before first iteration (2) ............................................. 88
Figure 35: Fiducial Markers .......................................................................................................... 90
Figure 36: Pasture/Sheep Hex-tile from Catan Map, (b) with ‘features’ ..................................... 91
Figure 37: Forest/Wood Hex-tile from Catan Map, (b) with ‘features’ ....................................... 92
Figure 38: Design Process: The First Iteration ....................................................................... 95
Figure 39: Design Process: The Second Iteration ..................................................................... 98
Figure 40: Options for Virtualbutton Layouts ........................................................................ 100
Figure 41: Notebook drawings for ideas during the third iteration ......................................... 102
Figure 42: Design Process: The Third Iteration ....................................................................... 103
List of Tables

Table 1: Observations and Insights ................................................................. 67
Table 2: Key observations and Interpretation ................................................. 68
Table 3: Interpretation and Inferences ........................................................... 69
Table 4: No of players and Board Game Popularity ......................................... 71
Table 5: Five Iterations at a Glance ............................................................... 94
Table 6: User Tasks and Results ................................................................. 122
Table 7: AR System Functions and Results Observed .................................... 123
Abstract

This research presents a new approach to using Augmented Reality for presenting and navigating through information in a scenario involving a board game. Learning the rules and strategies of a new game can be a challenging task for players. In particular, this can be an intimidating task for people who do not regularly play board games. Many board games are complex and new players require several sessions to learn them to be able to play at a reasonable speed while providing a challenge to experienced players. New players generally prefer not to read the manuals and instead learn to play the game on the fly and by asking experienced players. Several issues arise here for more experienced players who need to explain the game rules on the fly and when explaining strategies.

This research therefore has been guided by the following question: How can an Augmented Reality experience be designed for board games to communicate information in an interactive and non-intrusive way? This has been addressed by conducting an ethnographic inspired study on public board game sessions and a research through design methodology.

The board game, Settlers of Catan was selected and the Activity Theory framework was used to explore the relationship between the components in a game session. Interactive augmented information overlays were designed using design principles of visual communication and information design. Guided by Flow Theory, the experience was designed to be in-situ and non-intrusive.

The research showcases my approach to use Augmented Reality as a medium for information, moving beyond the focus on enabling technology. Innovative approach for video capture and for occlusion-based navigation of augmented content has been demonstrated through the process of design and the subsequent development of a series of software prototypes. I have used Research through Design as the methodology for generating new knowledge through five design iterations of a software prototype for the game Settlers of Catan, and evaluated the prototype through peer-review and user testing.
Chapter 1
Introduction

Overview
In my research I have attempted to utilise the benefits of Augmented Reality to alleviate problems that can occur if people with different experience levels try to play a board game. Whilst there are game manuals and other learning aids available they are often not sufficient to prepare a new player to become a challenging opponent for experienced players or even to win the game. This chapter begins by defining and briefly describing Augmented Reality, followed by the significance of this research. Next, I describe the scenario of a typical board game session followed by a brief introduction of the learning aids that are available to new players. Then I describe the limitations of these learning aids, along with the general issues that arise in the scenario. Next, the research question formally defines the problem statement. The chapter continues by briefly introducing the methodology that was followed in this research project. The research project also involved the design and development of a software prototype, and I briefly present the findings and contribution of this research. The chapter concludes with a summary and an outline for the exegesis.

1.1 Augmented Reality
Augmented Reality is defined as a technology which allows computer generated visual imagery to exactly overlay physical objects in real-time (Zhou et al., 2008). Augmented Reality (AR) is enabled by a set of technologies that gather input from the real world through sensors. This input is synthesised and digital content is rendered to the objects identified in the real world. It thus creates an illusion that the real world objects and digital objects coexist. Various attempts are made to make the digital
objects render correctly (Gibson & Chalmers, 2003). In a landmark survey, Azuma (1997) provides a
definition for Augmented Reality and defines that AR systems have the following three
characteristics:

1. The system combines real and virtual
2. The system is interactive in real-time
3. Augmented objects are registered in 3D

This is the dominant technical definition for AR. This research assumes a broader understanding of
AR that understands AR as part of context-aware computing. Pascoe (1998) defines Context-
augmentation as part of a proposed taxonomy of context-aware features, as “the ability to associate
digital data with a user’s context.”

Attempts have been made to use AR for various industrial applications since 1990s, but with the
recent mass-production of powerful smartphones, AR has been brought to the mass market in the
hands of consumers. With interest in wearable computing devices, specifically smart glasses which
are poised to reach mass market soon, AR has potential to be a mainstream technology for end-user
applications in general everyday situations. The key value addition in using AR technology is the
ability to augment the physical world with digital information, and thus aid in learning and
supporting task performance, as shown in various studies of industrial processes in Henderson and
Feiner (2011), Ong et al., (2007). However, till date AR research has explored simple information like
pointers and annotations being overlaid onto the physical world as augmentations, and not complex
information that warrant multiple overlays that include text, visuals and animations, as in a case of
board games.

This research employs context-aware-augmented-reality. It makes use of some augmented reality
techniques, specifically the video overlay approach, in a non-conventional manner. A review of the
history of AR development is presented in the next chapter where I discuss in detail the current state
of AR, and current attempts at broadening the technical definition of AR, and the general AR trend
towards becoming a medium. In the following section I continue the discussion on AR and introduce
the motivation of for conducting this research project.

1.2 Significance of this Research
This research is a study into AR using a board game as a case study. In this research I have
endeavoured to simplify a new-comer’s participation into a new activity system that follows specific
rules by using an emergent technology. In particular, the chosen scenario is a new player at a board
game supported by information on the rules of the game, as well as a basic strategy, using AR as a
medium rather than a technology.

Thus the importance of this research can be explained in two parts:

- The problems, issues and challenges it attempts to address and resolve for people and the
  chosen activity system.
- How these problems, issues and challenges can be applied to other fields.
- The basis of a new opportunity for the field of augmented reality.

The problems, issues, and challenges are explained in detail in sections 1.4, and 1.5. Here I discuss
how the chosen scenario and case, i.e. board games, has yielded findings that can be applied to
other contexts outside gaming, such as education and training. Board games offer a short session
with a myriad of interpretations. These factors differ from game to game, but generally, people play
board games to socialise and have fun, and / or to learn, analyse and eventually, compete. These
factors can be mapped to a host of everyday activities that involve familiarisation to a
place/instrument's ways to navigate or interact, and knowing enough to actually act towards
reaching your goal. The issues and problems faced in these everyday situations can be mapped to a
board game, and the findings, in turn, can be applied to contexts outside board games.

This research has potential in industrial AR applications where users are involved with assembly
processes (Henderson & Feiner, 2011; Ong et al., 2007). The tasks in assembly process require
temporal and spatial ordering of subtasks that including choosing the correct part from several
options, knowing the function of the part, and acting in a manner that places the part in the desired
manner. Scenarios involving operating a complex task being performed by a user through a control
panel consisting of several buttons that must be pressed in a correct order, such as a pilot’s pre-
flight check or the start-up sequence involving complex machinery are also potential applications of
this research. Marner (2013) explores the use of Augmented Reality using spatial annotations on
buttons of a control panel. The tasks performed by users using the AR system developed for this
research include choosing the correct spatial actions on the board game map by acting on sub-
decisions made that require temporal ordering of moves following a basic game strategy. These
tasks are similar to procedural and assembly processes in nature, and although the scenario is very
different concerns of the new player that are explored in this research and the insights gathered that
reveal how AR can support actions in a new environment, can help inform the design of industrial AR
applications. While in other research in similar scenarios thus described the focus is on the task and on the technology, I have kept my focus on the user and the scenario.

The new opportunity in the field of AR is based on the recent shift of focus from using the technology for visual effects, towards the creation of a learning experience. This was attempted through using AR as a medium for information by focussing on the design of an application and was enabled, in part, through the increase in computing power and quality of sensors over the last few decades. Technical issues such as the registration and tracking of physical objects nowadays is straightforward and therefore the focus of AR applications and this research project remained in the design and the scope of its value addition to a scenario.

1.3 The Typical Scenario of a Board Game Session
Unlike many computer games, a typical board game session requires two or more players, a game board and game tokens. In the following let’s imagine the player interaction and the flow of events during a board game session when players begin to play a game. Each player is handed game tokens and / or cards to play the game. It is not unusual that each player has a different level of experience with the board game and also uses different strategies to win the game. There are players that are more experienced and who are more familiar with the game and players who are new to the game and have not played the game before.

People play board games for various reasons. Board games provide an easy way to have fun with family and friends, and they require us to think, and act in a framework in a friendly competition. Experienced players, who regularly play board games, are motivated either to win, or in the case of complex games, try out new strategies, or simply to escape the routine of daily life. Often before the start of a game, the rules of the game are discussed between the players to make sure everybody is aware of the game rules. At this stage, the experienced player often points to cards and tokens, arranging them in a certain manner to explain certain points of gameplay. Strategic games are often complex and it can take a long while to go through all the rules necessary for starting the game. The agreement between all parties on the game’s rules is very important, and has a great impact on whether the players will enjoy the game or not.

In the following I highlight general factors and events that I have observed in board game sessions under “typical conditions” that include people who play board games regularly at public gatherings or between family members. These board game sessions are not to be confused with board game
competitions or sessions in which board gamers gather regularly to play deeply strategic role playing games. These factors and events shall be elaborated on in later chapters.

1.4 Manuals, Tutorials, Learning from Players
New players need to learn the game rules in order to play the game, and more importantly develop a strategy that increases their chances of winning. To do this, new players can choose between three options:

1. The player can open the game manual and read the rules.
2. The new player can look on the internet for game tutorials – resources are plentiful for popular games, but this requires a mobile device and internet access.
3. The new player can learn the rules from experienced players.

The experienced player often conducts the task of teaching the rules to the new player. The other players who are familiar with the game are involved intermittently in explaining the rules, with their affirmation on some points and sometimes they provide tips on specific game elements. In this scenario, the game manuals are often not referred to, nor are the online resources useful in this situation. It might take too long to read the manual, or access online resources through a computer because there is the process of accessing the media, and searching for the information which takes time. Moreover, learning requires time. Furthermore, as the information in the game manual is disconnected from the physical representation on the board game, it is not unusual that a new player prefers to ask the expert for clarification throughout the game.

1.5 New Player Problems
New players have to relate the information from the game manual, in the form of textual descriptions, and/or images and diagrams, to the physical game tokens and cards. The information on how to play a game, however, is often scattered throughout the manual. Moreover, the process of searching for relevant information in the game manual can be a cumbersome task. It is therefore quite rare to see a new player consulting the manual for information.

Clearly, new players face the obvious problems in the case of using the manual or the Internet tutorials, that information in both cases is detached from the place of action, the game board. This
can lead to perceptual and cognitive discontinuities that make it hard for new players to learn a new game.

New players therefore often prefer to learn from one or several experienced player(s). The experienced player uses the game tokens and acts out a few game scenarios to explain the game concepts and the links between them. There are two factors at play here. Firstly, the narrative flow of the experienced player, who creates an ad-hoc “tutorial” for the new player, and secondly, the capacity and manner in which the new player receives the information and develops relationships between the rules of the game and the physical board game itself.

This often results in the new player being overwhelmed by all the new information and becoming tired of learning all the rules. Often, game rules are learned by new players during a game: During these moments you often hear a new player say: “Let’s just start the game, and I will learn as we play along.” The experienced players also want to get on with playing the game. However, as the game starts new players often seek clarification and guidance as their turn approaches and also while it is their turn. This is not only time consuming, but also provides experienced players with an opportunity to provide advice that works in their favour.

The issues become more acute at the start of the game. New players can initially be very dependent on the experienced player to obtain information. The experienced player, however, is not only supposed to provide information to the inexperienced player, but also needs to provide fair advice when it comes to strategic thinking in the game. The more strategic advice the experienced player provides, the more the experienced player’s chances of winning the game are reduced.

Such game sessions would be played as a “learning session,” for new players, with the hope that the new players learn the game well and enjoy the game enough to play it again. Only if the game is played again, the experienced players, who have invested time in teaching the game, will be presented with a greater challenge from the new players.

The concept of Flow was defined by Mihaly Csikszentmihalyi (1990), who investigated why people spend large amounts of time and effort on activities that are challenging and require skill from the person to be rewarding. Csikszentmihalyi observed characteristics of flow experiences, which are the same all around the world for people engaged in different activities. The characteristics of a flow experience are defined as follows:

1. a task that can be completed;
2. the ability to concentrate on the task;
3. that concentration is possible because the task has clear goals;
4. that concentration is possible because the task provides immediate feedback;
5. the ability to exercise a sense of control over actions;
6. a deep but effortless involvement that removes awareness of everyday life frustrations;
7. concern for self disappears, but sense of self emerges stronger afterwards; and
8. the sense that the duration of time is altered.

In the current scenario involving board games, both the new and experienced players are not likely to experience flow because of the considerable uncertainties for them concerning the characteristics of a flow experience. The factors are discussed below.

The primary concern of new players is the time it will take to complete the game. They are concerned about their ability to concentrate on the task, and if they will find the task (game) interesting and not too complex. New players need clear goals, but how are these goals generated? Are they supposed to make goals for themselves, or should they be told what their goals should be throughout the game? The ability to exercise a sense of control is important. If they are told what they should do too often, new players can feel uninvolved in the game and thus lose interest.

Involvement in a new game should be effortless, but new players are not too concerned about removing the awareness of everyday life as they are learning the game, and for this same reason, the sense of duration of time altering is also not a goal for their first game. This may be a goal for their involvement in a board game, or board games in general as a recreational activity, but at a later stage that comes after they have learnt the game.

On the other hand, experienced players may find it difficult to concentrate on the task because they are interrupted by new players who are seeking to clarify their doubts as and when they understand certain game concepts. The ability to exercise a sense of control over their own actions is not a problem for experienced players, but going beyond it can be. New players often ask experienced players for their suggestions and advice on high-level game strategies. If experienced players inform the new players’ strategy too much, they can control new player’s game as well, which is not the point of a game at all. These issues can make experienced players play differently from their normal game, as they would play if all players have a similar experience level in the game. Their involvement in the game would not be deep and effortless, but orchestrated like a performance. Finally, if the game is not moving at a regular pace turn by turn, the sense of duration of time does not alter. What Csikszentmihalyi means by this is that the attention and focus of the players is so much on the task at hand that they may not notice the passage of time. If all players are enjoying the game and are deeply involved in it, many hours may pass but to them it may not seem that long. But an opposite
experience is also possible and it often occurs in this scenario. If players are not enjoying the game, time seems to drag on, which further results in an unpleasant game experience.

1.6 Methodology
This section very briefly describes how the research was conducted. The methodology followed was research through design. Through the process of a systematic inquiry by the practical act of designing, this research has generated communicable knowledge (Archer, 1995; Downton, 2003) in the form of the software prototype and this exegesis.

With the technical potential offered by AR, I ask: How can an AR experience be designed for board games to communicate information in an interactive and non-intrusive way?

The first phase of the research project was motivated to find an appropriate technological intervention in the real world situation involving board games. Data was collected from real-world game sessions through a method of exploring cultural phenomena in the context of board games. It relied on the researcher generating a written account of the social activities in naturally occurring settings (Brewer, 2000). The activities that occurred in board game sessions had a rich social overlay and thus the participant observation method of data collection was appropriate to inform the design of the digital intervention introduced by this research project. The data collection was conducted over a time frame of 6 months to gain a better understanding of the application domain of board games. This informed the choice of a suitable board game as a case study, and a design outline for the development of the software prototype.

The second phase of the research employed Activity Theory as a tool for analysing the components of the scenario that included the game and its elements, players and the social setting. Activity theory is a social theory that focuses on human activities in complex, socially situated phenomena. The key concepts of activity theory as presented by Kaptelenin and Nardi (2006) were used to inform the design of the software prototype. Activity theory was also used as a tool for analysing board game sessions as an activity system, as described by Mwanza (2001). Both these sources build upon Engeström’s development of Activity Theory since the 80s (Engeström, 1987). The activity theory based analysis informed the first steps taken to build the software prototype.

In the next phase, this research followed the constructivist learning theory, which regards learning as an active process of creating, rather than acquiring knowledge. “A learner constructs meaning through the experience of interacting with an environment and the subsequent reflection as a
reflective conversation with the design and on the design process” (Schön, 1995). This research follows the iterative design process with the decision sequence of problem, analysis, synthesis, and evaluation (Lawson, 1997). The contribution of this research is the use of design as a method of inquiry. It generates communicable knowledge through the practical act of designing (Downton, 2003).

A modified industrial product design process was employed to design and develop the AR system, ‘Catan-QuickStartAR’. The design process exists in many variations, each of which is suited to work with the particular factors involved in making a particular product. Generally, the process has the following steps, based on Costello Design (2002):

1. Research
2. Concept
3. Design
4. Development
5. Design Documentation
6. Prototype
7. Engineering
8. Production
The design process used in this research involved seven steps in one iteration, as shown in Figure 1. The process is a cyclic process where the last step of an iteration informs the first step of the next. A total of five such iterations were conducted to arrive at the final version of the prototype.

1.7 Findings and Contribution
In order to validate this research which involved a major component of design-based development of an AR prototype system, tests were conducted with users. The testing procedure is described in detail in Chapter 7 and the test documentation is presented in Appendix IV. Here, I provide a summary of the findings and the contributions made by this research.

The concept of ‘Flow’ as discussed in section 1.5, has not been used as an evaluation criterion for this research because it is too general in its characteristics. Instead, the following specific criterion are used for evaluation of the AR system that helps new players play a board game they have never
played before against experienced players: choosing the correct tasks, forming a basic game strategy, temporal rearrangement of information given by the AR system in response to the changing state of the game board, and the speed. The AR system helped users in their first game against experienced players. The tasks performed by users were basic tasks like choosing the correct options for their actions on the game map, which was performed with a 70% success rate, and complex tasks like reordering of information received through the AR system in response to changing game situation, which was performed with 75% success rate. All participants played with reasonable speed. These results are discussed in detail in section 7.4.

The major contributions of this research are:

- A prototype demonstrating how manuals can be replaced by AR in board games that involve a map component through the display of contextual information directly on physical objects
- A change in understanding of AR as a medium of information which opened up new areas to explore:
  - AR menu design – augmented menus that have buttons for switching between different layers of information.
  - The role of Visual communication to provide large amounts of information in AR applications
  - View management – The detachment of video feed in regards to the output/display and this resolving technical challenges of tracking and providing a more stable AR experience.
  - Occlusion-based triggers: a mechanism to gauge user intent by designing a region of the physical world as a hyperlink to information.

1.8 Chapter Summary
This chapter provided an introduction to the research, as well as an executive summary of the methodology followed. It described the situation of the research project and its relation to real-world applications. Then the motivation for this research was described in an alternate scenario that involved enabling the new player with an AR system, followed by research questions. A brief description of Augmented Reality introduced the technology used in this research project. The methodology has been described with an overview of the phases of the research and the theories and methods employed. Next, I describe the findings and the contribution of this research.
1.9 Exegesis Outline

The structure of the exegesis is as follows. Chapter 2 provides an overview about relevant research in AR and its current trends; along with related work concerning the chosen scenario. Chapter 3 describes the methodology followed by this research in detail. The next three chapters describe the methods and theories employed in this research. Chapter 4 describes the ethnographic inspired study conducted to observe board game sessions. Chapter 5 describes how Activity Theory was used as a tool to analyse the components of the scenario. Chapter 6 describes the design process and each iteration in detail. Chapter 7 presents the testing of the AR system with users, and the findings. Chapter 8 concludes the exegesis by presenting the contributions made by this research and suggests directions for future research.
Chapter 2
Background and Related Work

Overview
This chapter situates the research project by providing information about Background, Literature Review, and Related Work. The first section provides an introduction to Augmented Reality (AR) as a technology and a field of research. The second section reviews similar research in the field of AR for board games. Lastly, the third section describes the tutorials that are available for the game Settlers of Catan (Catan) and discusses their limitations and illustrates an opportunity for an AR-based tutorial for Catan.

2.1 Augmented Reality Definition and Examples
AR is a technology which allows computer generated virtual imagery to exactly overlay physical objects in real time (Billinghurst, 2008). Azuma (1997) states that AR systems

(1) combine real and virtual imagery
(2) are interactive in real time, and
(3) register the virtual imagery with the real world.

The term “Augmented Reality” is believed to be coined by Tom Caudell former researcher at Boeing (Caudell, 1992). Figure 2 shows an image of a technician using an AR system. The task of constructing an airplane is enormous. There are hundreds of wires running several metres throughout the body structure. In order to simplify the identification of the wires and other components, an AR head-mounted display (HMD) was used. The HMD would overlay information about the wires and other components directly on the physical wires, thus saving time and helping reduce errors.
AR requires hardware components for input and output. Input components can include a webcam and other imaging devices, accelerometer and other sensing devices and a computer where these components are connected. The computer processes the input signals and synthesises the real-world scenario for the AR software. The software then generates an image overlay scene and ensures that the overlay scene stays registered to the input in real-time. This combined scene is then displayed on output hardware such as a screen. The most common applications of AR systems have a live camera view with augmented content overlaid on physical objects.

**Commonly known examples of AR:**

The Sword of Damocles, by Ivan Sutherland and Bob Sproull is considered to be the first AR head-mounted display (HMD) system seen in Figure 3. This work is often credited as inspiration for Sutherland’s idea of the ultimate display (Sutherland, 1965). The central idea of Sutherland’s Ultimate Display was the creation of a non-distinguishable mixed reality where there is no difference between the real and the computer-generated objects. This HMD was too heavy to be head mounted, and thus it was suspended from the ceiling, hence the name: “The Sword of Damocles”.
The idea of augmented reality is also popular in movies. The image in figure 4 shows the Terminator T-800’s augmented reality view as a computer processing what he is seeing in the world (Cameron, 1992). The software in the movie was able to recognise the shape of a motorcycle, despite it being occluded by another motorcycle. The text represents some data that is retrieved from the motorcycle in view.
More recently, an AR display is seen in the popular Iron Man movies (Favreau, 2008). Figure 5 shows a scene representing the vision of Tony Stark from inside the Iron Man suit. The information displayed is registered to the physical space.

![Figure 5: Ironman’s Heads-up-Display from the Iron Man Movies (2008, 2010, and 2013)](image)

Augmented Reality is a critical component in the cockpit of fighter jets. Figure 6 depicts a heads-up display of a fighter jet. The display overlays real-time computer-generated information directly on the pilot’s view of the world. Critical information like the altitude and the line of horizon when superimposed in this manner saves precious time in looking away from the window to a control-board.

![Figure 6: Heads-up Display (HUD) of a Fighter Jet](image)
AR technology has also been successfully used by the movie industry in the actual process of making the film Avatar (Cameron, 2009). In figure 7, the assistant director for the popular Hollywood blockbuster Avatar shows Simulcam (Gupte, 2012; Dubska, 2013). The movie Avatar consisted of large amounts of computer-generated imagery in the form of characters and locations. The Simulcam is a special type of camera invented for the movie Avatar that helps the director to see the computer-generated imagery directly onto the camera display as the filming is going on. This enables the director to see in real-time how the scene would look in the final cut of the movie. Without this, the director had to visualise all the computer-generated elements of a scene in his mind. Using the Simulcam provided more control over the composition of the scene.

The promise of a standard outdoor-AR browser application can be seen in Figure 8. Overlay tags appear on the view of the physical world, and these tags are registered to the physical objects and spaces, so they would move as the user changes the view. Such AR browsers are widely popular in the smartphone market. The recent mass-market consumption of powerful smartphones has helped AR to come out of research labs into the hands of everyday users.
Google is famously working on making HMDs mainstream through a project called Google Glass, adorned in Figure 9 by founder Sergey Brin (Google Glass, 2014). Prototype videos show data from the internet relevant to the user being overlaid on physical spaces in real-time. At the time of writing of this thesis, Google Glass was not yet commercially available in the market in all countries.

Going further, Meta’s SpaceGlasses (Meta, 2014) promises an entire PC/tablet experience through their glasses. Figure 10 shows an illustration of the glasses with components. SpaceGlasses boast a stereoscopic 3D holographic display, and interaction with the information is done through gesture tracking. These glasses may deliver a better augmented reality experience than Google Glass.
because the display is considerably larger and stereoscopic. Meta SpaceGlasses were not available on the market at the time of the prototype development for this research.

![Figure 10: Components of META’s Space Glasses](image)

### 2.2 A Brief History of AR

The idea of augmenting the physical world with computer-generated information is a philosophical one. The Sword of Damocles, mentioned in the previous section, was the first demonstration of a working AR system. The experiment was born from Sutherland’s philosophical goal of creating a space where the real and the computer-generated objects share the same properties. In his essay, ‘The Ultimate Display,’ (Sutherland, 1965) he muses on the advances in display technologies that have “area-filling capability,” moving beyond the line-drawing and curve-drawing capabilities of the displays at the time of the writing of the paper. The insightful paper moves on to describe the technologies that we use today indifferent forms. The paper concludes by describing ‘The Ultimate Display’ where computers can control the existence of matter.

Arguably, the paper predicts a range of today’s technologies from graphical user interface (GUI) to high-definition displays, from gesture control technologies to GUI to the vision of tangible bits developed at MIT Media Laboratory (Ishii, 1997). Whilst it might be beyond the scope of AR to become the ‘Ultimate Display’ as it may not be able to control the existence of matter in the future,
the taxonomy of visual displays (Milgram, 1994) as displayed in figure 11, however is useful to define the scope of AR applications. On the virtuality continuum, Augmented Reality sits closer to the real environment than to the virtual environment.

Boeing was the first company to use an industrial AR setup in their processes of making airplanes. Described in the previous section, Boeing used a HMD-based AR system that helped technicians in the wiring of the aircraft. The system was used in the late 80s.

In the 90s, more industrial setups based on the AR technologies were developed. Azuma (1997) provides a landmark survey in which he describes the AR systems being used in fields such as medicine (Bajrua, 1992; Kancherla 1995); manufacturing and repair (Caudell, 1992); annotation and visualisation (Fitzmaurice, 1993); robot path planning (Drascic, 1993; Milgram, 1993); entertainment (Maes, 1995); and military (Wanstall, 1989).

Hardware miniaturisation and faster processing speeds made it possible for AR to be deployed on backpack computers, instead of the costly installations that are described in Azuma’s survey. ARToolkit, a computer vision based marker-tracking library was developed by Hirokazu Kato and Mark Billinghurst (Kato & Billinghurst, 1999). This library opened up the AR development to the individuals and labs interested, through a standardised tracking library. ARToolkit had computer vision algorithms that delivered sophisticated tracking of physical markers as seen in figure 12.
By the late 90s, academic conferences in AR were being conducted. The International Workshop on Augmented Reality (IWAR) was held in 1998, and the International Symposium on Mixed Reality (ISMR) was held in 1999. In 2002 both these conferences brought together as the International Symposium of Mixed and Augmented Reality (ISMAR), and now it is conducted every year. Organised by IEEE, it is the leading academic conference in AR. A 10 year review of the trends in AR as presented in ISMAR is presented in a survey (Zhou et al., 2008). The survey focuses on the areas that have been explored in AR, the developments and key problems in these areas, and the future trends of AR research.

The next major push to AR was received through the mass production of powerful smartphones and tablet computers. Widely available since 2009, the smartphone platform provided an opportunity to bring AR to the mass consumer market. Currently, there are several AR browsers available for smartphones, such as Layar, Wikitude, and Junaio.

Software development kits are freely available for making AR applications. With the recent trend towards wearable computing, mainstream wearable computing devices are at the horizon.

In this context, the following definitions of key terms are used throughout the exegesis. The meanings of the terms vary among the reviewed AR literature. This research understands the meaning provided as follows:

---

• **MEDIATED REALITY/ MIXED REALITY.** Older variations of the research areas now included in Augmented Reality.

• **VIRTUAL REALITY.** When AR was an emergent field of research, it was considered to be a variant of virtual reality. The major difference is that in VR the user is completely immersed in a simulated environment, while in AR the user is allowed to be present and act in the physical world.

• **VIDEO-PASS-THROUGH/ MAGIC LENS.** A common approach used in AR application where the mobile device is used to capture moving images and virtual information is overlaid on the display, thus allowing the device to be a “magic lens” into the real world. This video-pass-through method has been commercialised through apps like Layar (2014) on smartphones.

• **TRACKING.** Gathering data about the physical world through the position of the device which allows the virtual imagery to be displayed correctly registered with physical objects. Tracking is performed using the following sensors, sometimes in combination: camera, gyroscope, accelerometer, global positioning satellites (GPS), radio-frequency identification tags (RFID), and other sensors.

• **OVERLAY.** A virtual layer is superimposed on the video feed so that the virtual objects align with the real world. Multiple visual overlays are often used in an application. Augmented content is also referred to as overlaid information.

• **COMPUTER VISION.** This field contains methods of acquiring and analysing data gathered by computer systems from the real world. This is a sensing method for many AR applications.

• **COMPUTER VISION TRACKING.** Within the computer vision techniques, image processing libraries have been developed to recognise certain patterns in physical objects. Previously, “markers” (simple geometric patterns) were used in the physical world to present augmented content. Presently, markerless tracking has become possible through advancements in hardware for input and processing, as well as more refined computer vision libraries.

• **OBJECT RECOGNITION.** A more sophisticated method of recognising patterns to determine objects in the physical world. Instead of markers, objects with sufficient detail are used to be recognised by the application. Object recognition generally requires more computing power then marker-based tracking. The advantage is that objects from the real world can be directly used for AR. This is the method used for this research.
2.3 Recent Trends in Augmented Reality

Google trends is based on data derived from Google search. Trends show how often a search term is entered relative to the total search-volume across the world. The horizontal axis represents time and the vertical axis represents how often a term is searched for relative to the total number of searches globally.

This discussion is relevant because augmented reality has a lot of market hype associated with it in the recent years. Market hype is generated by “promise champions” for new technologies. This hype is important because it shapes academic research, which includes motivating researchers to start on a certain research topic, including this research.

The following graph hints at global interest for augmented reality. For the 2004-2009 period the interest is very low, but suddenly in 2009 interest grows considerably (Figure 13). This can be attributed to powerful smartphones becoming commonly available. Heralded by iPhone 3G, phones become feature-rich in terms of sensors and displays. These are the key enabling technologies for augmented reality, thus an association can be made between the mass-market availability of these devices to the interest in augmented reality.

Post 2012, the graph dipping down, and presently the interest is roughly where it was back in 2009. Interest in AR can be said to be dwindling. To compare, consider the following graph in figure 14.

The red line indicates interest for the term “cloud computing,” which also saw a rise in 2009, but has sustained global interest till date. For augmented reality, the promises that have been made include the reversal of the migration of public discourse in the virtual sphere. Through AR, the collective information from the Internet can be overlaid back into the physical environment. It has been called
the next mass medium (Ahonen, 2012). The market interest is important for academic research, which has certainly been the case for this research in terms of the software development environment used. The AR system was developed using Vuforia SDK (Qualcomm Developer Network, 2014). Vuforia emerged out of the company’s strategic investment into AR. For researchers it offers a comprehensive package of computer vision libraries and options to work in popular 3D modelling programs like Unity, and maintains a vibrant developer community. A detailed introduction to the software development environment is presented in Chapter 6. The point to note here is that market interest in AR is going down, which may affect its development for the coming years.

![Figure 14: Google Trends Graph for “Augmented Reality (blue)” and “Cloud Computing (red)”](image)

Snapshots of AR development viewed through two AR Surveys

1. Ronald Azuma paper (Azuma, 1997): This paper first provides a definition of augmented reality and is thus, arguably the starting point of modern AR. The paper is a survey that describes AR and the experiments/installations in the 90s, and compares them to mainframes development, where only few users were trained to use the technology at a time. The paper concludes by pointing out that the main problems for building effective AR systems are: registration, sensing, and tracking.

2. Zhou et al. (2008) presented a survey of mixed and augmented reality. The survey was an excellent source for statistical data for academic research in AR, over 300 papers have been covered. Most AR systems running from backpack computers. Similar to Azuma’s review, the main limitations of AR were still registration and tracking. Zhou and Duh et al. (2008), however also pointed out that interaction is a problem.
In summary it seems that most technical problems have remained the same in the 10-year period between the reviews. However, hardware and software platforms have evolved immensely and today, the scale of devices powerful enough for AR are so small that they fit into the palm of a hand.

Interestingly, the Arts, Media and Humanities segment does not feature at the yearly ISMAR. The statistics AR research trends from the 10 years review (Zhou and Duh et al., 2008) suggest that research on these topics, if presented, would have constituted less than 2% of papers of the over three hundred papers presented at ISMAR. The segment was introduced in 2009, and is now established as a proper program for the symposium. Moreover, ISMAR 2014 presents an expanded scope, following its theme to augment everything, everywhere for everyone, “specifically inviting contributions from emerging areas”. It can be inferred that the concerns regarding design for AR and AR-as-a-medium are gaining increasing interest in the academic community.

Azuma stated at ISMAR 2010 that the mobile phone mass market has a huge impact on the interest in AR applications (Azuma, 2010). However, Azuma points out that advancements in art and design were required to create the experiences, and the business model to take AR experiences to the mass audience. At AWE 2013, Mark Billinghurst, an AR veteran, notes that due to miniaturised hardware, AR has gone into the commercial marketplace and that a large number of companies are now working on AR applications (Billinghurst, 2013). However, Billinghurst mentions that many designers who work in the AR space are not comfortable with the development and that AR design guidelines are needed. Billinghurst defined the guidelines as follows (Billinghurst, 2013):

1. Know the technology
2. Design for all aspects of user experience
3. Follow interaction design principles
4. Consider all design elements
5. Know future research directions.

It is clear that for AR, to advance and to become a medium, design-led investigations are important. This research project uses the design-led investigation to progress knowledge and adheres to the design guideline defined by Billinghurst (2013).
2.4 Related Work

In this section I document the literature review conducted in order to define the scope of the AR intervention for a board game. There are four sub-sections. First, I present the use of AR in assembly processes and industrial maintenance scenarios. The second section presents a review of Spatial AR applications and current research. The third section presents a brief discussion on learning theories and how they have informed this research. In the final section I present implementations of AR for board games and discuss how this research is new and adds new knowledge to the field.

2.4.1 AR in Assembly Processes and Industrial Maintenance

This subsection presents a review of various user studies conducted on AR systems implemented for assembly processes. This kind of implementation of AR is important for my research as the focus is on users and task performance. A board game can be seen as an assembly process - there are various components that the users have to choose from, they should know the function and purpose of these components, and use them in the correct position/sequence for successfully conducting a task and achieving a goal that may be comprised of several of tasks.

Tang et al. (2003) present a user study comparing AR with other forms of media for assembly tasks. They compare a head-mounted AR display with a printed manual and computer-assisted instructions displayed on a display monitor. The task involved a 56 step procedural assembly of Duplo block. Their results indicate that AR can significantly reduce the error rate in the task compared to other media by 82%, and an improvement in task performance is directly afforded by overlaying meaningful information on physical tasks. Their results are limited by the technical factors like display and calibration technologies. The probable reason for this is that they were using the more computationally intensive marker-less tracking. The vision processing algorithms and camera sensors were not capable at that time. Additionally, they use a HMD which affects user performance due to its limited field of vision and weight.

Haniff and Berber (2003), present a comparative study of a pump assembly task using AR and paper-based instructions. They conclude that the paper-based instruction method resulted in faster performance over AR system. The failing of AR systems was partly due to the technical shortcomings, however the authors mention “participants were positive about AR, and appreciated its usefulness.” This could be attributed to the reduction in cognitive activity reported by the users when using AR over paper-based instructions.
Another user study which indicates users preferring AR over traditional mediums of instruction is presented in Gauglitz et al. (2012). This study involves 48 participants in the task of operating an airplane cockpit when being instructed by a remote expert. They compare three viewing mechanisms: video only, image-based AR annotations and world-based AR annotations. They report significantly higher task performance using image-based AR annotations and world-based AR annotations over video. 79% of users are reported to have preferred their prototype despite the technical limitations in tracking physical objects.

Schwerdtfeger and Klinker (2008), investigate the use of HMD-based AR systems in an assembly task focused on order picking. Their focus is on different visualisation mechanisms for providing annotations on physical objects, indicating that the form of presentation is important when designing AR overlays.

These papers indicate that AR setups still face significant technical challenges in registration and tracking, but interestingly are preferred by users in almost all cases over traditional media of instruction such as manuals or video. The strength of AR is in providing meaningful information as an overlay on physical objects, which is not possible using any other medium. These papers informed the considerations for the shape and platform of the AR system I have built for this research. I have avoided the use of HMDs as they are clunky and expensive, and have instead focused on a handheld for AR application, and subsequently developed a fixed-camera spatial AR setup.

### 2.4.2 Spatial Augmented Reality

Bimber and Raskar (2004) have defined Spatial Augmented Reality (SAR) as a set of technologies that allow physical objects to be augmented with computer generated images, usually through projectors that can give different colours and apparent textures and other cosmetic detail to physical objects.

The difference from “normal” AR is the construction of a physical environment where a limited number of objects are enhanced by digital content like images, 3D content or animations. The key benefit of SAR is that the user does not have to wear a head-mounted display, or use any other handheld-display.

**SAR support for design of complex physical environments**

Thomas et al. (2011) present design concerns for complex physical environments using computing technologies, specifically SAR to bring digital content onto physical spaces and objects. Their discussion seeks to provide a framework for the development of design tools for SAR. Their focus
remains on the design processes for SAR environments. They cite the three main artefacts that have to be considered for SAR rapid prototyping: the prototype itself, the technology infrastructure, and the toolset that allows designers to create these prototypes. Their main motivation in using SAR setups is the collaboration between multiple users possible with augmentations which can foster good design by allowing all users to interact with a single mixed reality view. They present a detailed description of a design scenario with a concluding summary of functions of SAR setups. The following functions are described in particular: to collect experience from shared space; to act as a simulation of the environment to try scenarios; and to test new capabilities; and finally, the design for decommissioning the setup. The focus on design in the paper gives voice to the idea that design is playing an increasing role in the final shape of AR setups. The study of the scenario where the AR technology is sought to be implemented needs to be thorough. In my research I have followed these ideas: I have spent over five months studying the chosen scenario to gather data to inform the guidelines in developing the AR system. This data is presented in Appendix IV.

SAR support for using control panels
Porter et al. (2010) present results of their investigation in the use of SAR in prototyping interfaces like control panels using finger tracking. Their aim is to avoid the construction of mock-up control panels in their design phase and using augmented control panels instead for prototyping. They have conducted tests with users to explore this idea. The results indicate that user performance with ‘virtual buttons’ is slower than physical buttons, which has been linked to the lack of haptic feedback when using ‘virtual buttons’ and shadows that are cast by their hands. However, it was found that the limitations did not affect the interaction adversely, and the authors concluded that SAR is a suitable technology for the rapid prototyping of interface design for control panels. This findings of the paper has informed the design of the AR system for this research project, specifically beyond the third iteration where ‘virtual buttons’ are used. Being aware of the shortcomings of ‘virtual buttons’ has informed the design of their optimal size.

Marner et al. (2013), present the results of a study that measured a procedural task performance using SAR. The task they gave users is fairly simple: pressing a set of buttons in the correct order on a control panel designed for the experiment. They compare results of using AR annotations on buttons against using a display monitor. The authors concluded that using AR annotations can improve task completion speed, and reduce errors. Their research informed the experiment design for my research, in terms of the procedure although the scenarios have been very different. It informed the
tasks I have chosen to measure user performance, specifically the first two out of five tasks (Section 7.1.3).

Because of the close proximity of the concepts of SAR with Tangible Interaction, there are many papers exploring physical-virtual tools that are used as a “stylus” for interacting with augmentations in AR interfaces. This is beyond the scope of this research project, but examples can be found in Bandhopadhyay et al. (2001), Jung et al. (2004) and Schkolne et al. (2001).

SAR, thus shows potential for practical applications because of its focused approach and its value addition through its approach to augment physical spaces with digital information. The setups are designed and built, and technical factors like the camera’s depth of field, the system’s sensitivity to detect patterns, and the projector settings are calibrated only once for a smooth technical performance. The limitation however, is that as the augmentations are projected directly onto physical objects and spaces, there are obvious issues in a multi-user scenario. Only one user can interact with the system in this case, and only that user can get the output from the system. Moreover, as the output is visible to all, the augmented information may perhaps distract other users who have no use of it, and thus it may unfavourably affect other users’ performance at the tasks in the space. Furthermore, if the nature of information needs to be private and not visible to other players, the SAR system is not suitable. In the scenario chosen for this research project, both these considerations feature prominently. The new player learns a board game through the AR system, but the information presented should not pervade the experience of other players. Similarly, the strategic help given to a new user should only be visible to the player needing assistance and not to other players. To address these issues, the augmented view of the physical space can be provided to the new player on a portable device, or a computer monitor in a manner that only the new player is able to see. Thus I present a special case of a spatial AR system, where the projector is not used and only the fixed camera for input along with pre-calibrated technical parameters like lighting and depth of focus of the camera are used.

2.4.3 Learning Theories
In this section I present a brief discussion on learning theories and how they have informed this research. Early learning theories include behaviourism, cognitivism and constructivism. Behaviourism (Skinner, 1984) assumes that the learner is passive, and only responds to environmental stimuli. It is based on the belief that all learners start at a similar “blank canvas” and behaviour is shaped through positive and negative reinforcement. Learning is defined by a change in behaviour as reinforced by a applying a stimuli or withholding it. This worldview was replaced by
Cognitivism (Mandler, 1985), which cast the learner as a rational being, able to perform mental process such as thinking and using memory. There is an emphasis on active participation for learning, and changes in behaviour are seen through actions as a consequence of thinking. Constructivism (Bruner, 1968) goes a step further and focuses on the process of learning, on how learners construct their own subjective representations of objective reality. This paradigm suggests that learning is an active, contextualised process of constructing knowledge, rather than acquiring it. Knowledge is constructed based on personal experiences through social interactions. This research project is based on the constructivist worldview.

Vygotsky (1980), a major contributor to constructivism is the founder of Activity Theory. Activity Theory is a comprehensive paradigm to explore concepts like people, activities, learning, etc. Activity theory was found to be suitable for this research because of its focus on the process of learning and on the learner’s construction of subjective representations of objective reality; and is further described in chapter 5.

Newer learning theories like connected learning (Ito, 2013), blended learning (Garrison, 2004), and informal learning (Marsick, 1990) are briefly discussed here with a focus on their relevance for this research. In connected learning, there is an emphasis on the learner and developing the learner's capacity to create, to navigate, and to operate in a world that cannot be fully understood. Connected learning is a model of learning that emphasises on social equity and seeks to mould the uptake of new technologies and techniques based on these commitments. It asks how we can use new technology in service of creating powerful learning experiences and in the service of broadening access to opportunity to those powerful experiences. It does not require a specific technology, platform or technique. It also does not require digital technology at all. It can be applied to sports, civic actions, games etc. While the notion of connected learning broadly applies to this research, its indifference to technology and focus on creating learning experiences makes it a less attractive option to be considered for further integration to this research. Connected learning focuses on social equity as well, and it uses technology to address concerns for social issues as well.

Informal learning is not organised like formal learning, and thus has no set objectives in terms of learning outcomes. Additionally, it is never intentional from the learner's standpoint. It is often referred to learning by experience. Informal learning is difficult to quantify or prove. In the present scenario, new players learn games by informal learning. They have no hard goals and have little in terms of intermediate goals while playing the game because they do not know enough about the game to set these goals. In the "problem scenario" learning, if that happens for new players, happens informally. This type of learning is time-consuming and irregular as players are trying to
unconsciously learn by slow experience. This research seeks to address and target this type of learning.

Blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path or pace. In education, classroom methods are combined with computer-mediated activities. The opportunity of data collection and customisation of instruction and assessment as two major benefits of this approach. Blended learning can provide insights for this research. The school/computer mediated activity can be translated in the chosen scenario as the social and formal gameplay activities with AR based hints and instructions. Data collection and customizations, the two major benefits are not currently applied to ‘Catan Quick-StartAR.’ However, the two major benefits can be contextualised data presentation, and multiple-access to information.

2.4.4 AR and Board Games

There have been several attempts at integrating AR for board games. An implementation of AR for the board game Monopoly is presented in (Molla & Lepetit, 2010). The authors use a webcam to detect the game pawns, and augment the pawns with visual effects. Their implementation, however, does not include a game logic. The focus is to increase player immersion compared to the original board game and provide a different experience than a video game, thus the game can reach a large audience. Magerkurth et al. (2004) describe using AR for board games with a stationary camera placed on top of the board. They use limited computer vision techniques and use radio identification for board sensing. Cooper et al. (2004) propose an AR system for Chinese checkers using markers. They explore user interface issues for table top projected AR entertainment applications.

An AR prototype game, ‘BattleBoard 3D’ is described in Andersan et al. (2004). The game prototype augments a traditional board game with features from computer games, like computer-generated imagery, 3D models with animation. Their goal was to enhance the game experience by combining the best features from classical board games and computer games. Physical factors like the placement of the players and the board game, social interaction between the players, are brought to an AR game. Setup uses markers and the ARToolkit.

Another implementation of a collaborative handheld augmented reality board game: Art of Defence is presented in (Nguyen et al., 2009). The authors define an AR board game as “a class of tabletop games which combine handheld computers such as camera phones with physical game pieces to
create a merged physical/virtual game on the tabletop.” Their goal is to explore the affordances and constraints of Handheld-Augmented Reality (HAR) interfaces for collaborative social games.

AR has potential in the board gaming industry, in creating mixed reality games, or AR games, as noted in (Szalavari et al., 1998). The authors construct an AR setup with multiple users with head mounted displays. Their implementation focuses more on the technical challenges faced at categorising public vs. private information in games like roulette and mah-jongg.

Implementation of the social aspects of traditional board games computer games is also found in Bjork et al. (2001). The authors design and implement a multi-player game ‘Pirates!’ on handheld computers, using radio-frequency identification tags (RFID) to sense player locations. The game is an attempt at using elements of the world as a game board.

A similar concept is described in (Thomas et al., 2000) implementation of the popular video game Quake using AR. The first-person shooter ARQuake allows the player to roam around in the outside world while playing a game in the computer generated world. The game monsters responded to the lighting conditions in the physical world to make them more visible. The implementation is very interesting, as it uses ‘the world as a game board’ in an innovative way.

Most of these attempts described implement AR in a similar way: to enhance the board game experience by computer generated imagery. It is acknowledged that the social aspect of board games creates a game experience that is difficult to achieve in computer games. The goal is to bring out physical board game elements into digital games. Elements such as player interaction and the tangible aspect of moving physical tokens are valued, and AR is used to provide surface enhancements to game tokens to achieve better immersion and player interest.

The aim of this research is different. This research is not an effort in the emerging area of mixed-reality games. Rather, as described in the next section, the research aims at using AR to provide an interactive game tutorial in a common game scenario involving a board game with players with different experience levels.

An AR implementation close to this research is the Audi’s AR manual (Audi, 2014). The manual is available for Audi A1 and A3 on the iOS platform and is developed by Metaio (2014). The application works by the user pointing her smartphone at a button or an indicator on the dashboard, and getting information about its function, as shown in figure 15. Also, pointing the phone under the hood, the system overlays labels over parts. This brings the information from the manual right on the physical tokens the user wants to inquire about.
An enhanced system has been developed for Volkswagen XL1 by Metaio, called Mobile Augmented Reality Technical Assistance, which shows step-by-step instructions on how to repair and replace certain components (Metaio, 2014).

This research project similarly provides a new player with an interactive tutorial for a board game in an attempt to replace the game manual, and other tutorials.

2.5 Board Game Tutorials and their Limitations

In this section I present a detailed analysis of the tutorials available for board games on different media. The scenario I am working with – a new player at a new board game – has been presented in Chapter 1 in detail, in conjunction with the options available for new players to learn the game and play, and the issues and problems in the scenario. The new player has to learn the basics of the game in order to play, but learning the game rules from the game manual is difficult as the source of information is different from the source of action and thus there are two problems: there is visual searching required in the manual, and the repeated shifting from one medium to another may affect
user performance adversely. If the new player asks experienced players, the experienced players may get tired of explaining the rules and may not be able to provide a good narrative to explain the game and sometimes, the experienced players may not know everything about the strategic elements of the game themselves. Furthermore, asking an experienced player multiple times can hamper the game experience. Similarly, strategic help can be problematic as well, as the more experienced players help new players, the more the experienced players will control the new player’s game. Experienced players will thus face a reduced challenge because they are fully aware of the new player’s strategy and may thus encounter little in terms of surprise. They may not find it necessary to play creatively by considering counter strategies. This results in a less than optimal game experience.

In the following I discuss three different media to learn the game ‘Settlers of Catan’ that are designed with different goals. The game manual is the exhaustive source of all game information in the printed form. The web and tablet assistants are designed as a “classroom” experience, but they require the use of a device for accessing them during game play. I present the functions and limitations of each method.

2.5.1 Settlers of Catan Game Rules and Almanac
The board game ‘Settlers of Catan’ contains a game rule book and an almanac. The rules book contains four pages with the rules of the game and the most critical information including a setup for beginners to learn the game. The almanac contains more detailed information about the game such as a list of game components, instructions to construct the island, and the description of each and every component of the game. Sample pages of the rule book are illustrated in Figures 16 and 17.
The game rules narrative is designed for the starting map for beginners (on page number 3 in the manual). The board contains hexagonal tiles that can be arranged in a random order for each game henceforth, but this board is set in that arrangement to have an equal distribution of the desirable spots to build on.

In addition to providing the fixed board arrangement for the first game, the manual also provides the starting positions for each player, as well as their second settlement placements.

Beside the map are tiny icons representing the resource card with the corresponding resource hexagon. This is critical information, and could have been better explained by larger sized images. Resource association can be a difficult task for first time players.
The next page on the manual describes the settlement placement rule. This rule is easily understood after one or two sessions but for the first game new players struggle with the logic behind it. This rule can be presented in a more elaborate manner for the first game for the new players. An overview of the turn actions is presented, and following that, the turn actions are explained in detail: resource production, trading, building and special cases: rolling a seven or playing development cards.

The four pages of rules make up about 2000 words, which at average prose reading speed of 250 words per minute (HFI, 2014), would take 8 minutes to read. As new players must understand the rules while they read, the process can take well over 10 minutes. Generally, when people meet to at a public game session, they want to play games and not wait for 10 minutes or longer until the new player has read and understood the game. It is therefore extremely rare to see beginners actually read the manual as the board is being setup.

The following eight pages of the manual contain the Catan almanac. It provides an indexed list of game components and their detailed descriptions with images. The information presented in these pages is critical for new players to develop a deeper understanding of the game components and how they interact, to make deeper strategies. Reading through the rules in the book alone to learn the game is not practical and new players need to act out certain scenarios on the board to
understand them. The almanac, being fairly long, presents a challenge for new players before their first game.

2.5.2 Prof. Easy Web Tutorial
Catan can be learnt through online sources as well. Numerous tutorials are available in the form of game enthusiast blogs, forums and videos. This section describes the official tutorial (Prof Easy, 2014).

The official version of the tutorial employs a narrative “walkthrough”, using a range of graphics and basic animations. The game rules are narrated by three player characters, and Prof. Easy intervenes intermittently with suggestions and advice. The tutorial is interactive and made in Java, and is capable of running on all web browsers.

On first impression, the tutorial seems simple enough, fun to interact with, and short – there are 35 slides. This section describes the beginning few slides of the tutorial to highlight the important features. As the style repeats throughout the tutorial, it is sufficient to analyse them and draw conclusions.

The following two images show the webpage where the online tutorial is hosted. Prof. Easy is the character that will take the user through the tutorial. The graphic style of Prof. Easy is different in these images: a rich-colour illustration in figure 18, and a thick-outline illustration figure 19.

Figure 18: Official Catan Online Tutorial
The first slide introduces the three characters, located next to the game board, similar to the arrangement of players around a game board in real life as seen in Figure 19 (a). The characters communicate the game rules to the learner through speech bubbles in graphic comics’ style. In Figure 19 (b), the character Vicky is giving an instruction to the user.

![Slide 1 of the Official Catan Web Tutorial](image1)
![Slide showing how to configure the map](image2)

**Figure 19: Official Catan Online Tutorial**

The map-frame is in the centre, and the user must click on it. The interactive nature of the space where the map frame is displayed features a flashing red rectangle, indicating the wait for user intervention. When the user clicks on the map pieces, a short animation plays out, and the result is shown in Figure 20 (a). The map pieces are in their positions. Next, the resource hexagons are placed in their positions in the same interaction style. This partially completes the map. A character then, invites the user to click on the different areas on the map to indicate corresponding resource cards as shown in Figure 20 (b).
The highlighted hexagons and resource cards flash in correspondence to indicate association. In Figure 21, one of the characters talks about the names of the resources and their production centres.
The rest of the information in the tutorial follows from here in a similar manner. These slides have all the features of the tutorial that are important from an interaction and information design point of view.

There are several issues with the tutorial. The graphic style between the elements of the tutorial is not consistent: cards appear as real-world cards, while players are 3D models. The 3D characters do not move, and speech is animated in a comic style. The inconsistency in the graphic style makes it difficult for the reader to be absorbed in the tutorial.

The narrative shifts from one player to the next, in a random manner. The major problem with the tutorial is the apparent random manner in which the narrative moves on, and the numerous “next” clicks the user must go through. Moreover, it is difficult to separate the information from the instructions. The random manner in which the narrative moves on makes it difficult to walk through. Furthermore, the numerous “next” clicks per slide lengthen the tutorial: what appears to be 35 slides at first is quickly extended to more slides. The extended length of the tutorial makes it a less attractive option for learning the game as players are keen to starting the game and learn as they play along.

### 2.5.3 Prof. Easy Tablet Application

The official Catan tutorial is also available on tablets (Google Play, 2014). As the tutorial features on a tablet device, it is more accessible and likely to be used in a real world scenario than the tutorial on the web browser.

The iPad-tutorial is an attempt to add more features to the web-tutorial. Here, Prof. Easy’s speech is read aloud. The information is similar to the web-tutorial as shown in Figure 22 (a), it begins with the construction of the island shown in Figure 22 (b), and identifying and associating resources. The navigation has only two options, next and forward. There are slides in which the user hears “follow these instructions exactly,” or different words to the same effect. The Figure 23 (b) shows a few oddities about the tutorial: it is too prescriptive. The players have to sit in a certain order, and the colours of the players’ tokens have to be in a certain order.
Figure 22: Prof Easy’s Catan Assistant on iPad – Welcome Screen

Figure 23: Prof Easy’s Catan Assistant on iPad - 2
The major limitation of this tutorial is the linear structure. The slides feature only next and back as interactive elements. There are no options to go back to a particular slide, the information is not categorised, and there is no table of contents. These things become crucial while considering the tutorial’s length: 95 slides! These are design flaws that go against design heuristics for information design for electronic manuals (Tselentis, 2012).

Despite these shortcomings, the tutorial has got largely favourable reviews (Catan Game Assistant, 2013). The reason for this may be that it is easy to go through the tutorial, compared to the rule book. Reviewers have commented on the limitations such as the strict step-by-step instructions that players have to follow, and the inability to navigate freely to a previous topic. However, the fact remains that using this tutorial is actually not practical for players when they go to a public gaming session. If you want to use the tutorial you need to play by yourself which goes against the fundamental idea of board games.
2.6 The Gaps and Challenges
This section lists the shortcomings of the learning and tutorial aids discussed in the previous section and explains how this research project addresses these issues through the use of AR. (i) The official Catan Manual is generally not a very practical reference for new players because of the amount of time it takes to read the information and the disconnection from the actual board game from the source of information. Moreover, the process of searching for particular information which involves user’s attention and focus, may affect user performance. (ii) The Web Tutorial presents an inconsistent visual style that does not help readability, and the length of the tutorial is also a potential problem for new players. (iii) With the Catan Tablet tutorial, all the above mentioned problems hold true, along with the inability to navigate through the tutorial freely.

Thus, the limitations of these tutorials can be summarised as follows:

1. Tutorial is in a different place than the game board – the place of action.
2. There is a process of searching required to access relevant information.
3. The information is linear and navigation is constrained.

An AR application could address problems (1) and (2) as follows. Information presented on an AR interface is by definition registered on the physical objects – thus there is no process of accessing the tutorial on a different medium (printed manual or web/tablet slideshow), nor is any searching required to access particular information. Information is presented in the mixed reality view right in the place of action. Moreover, as this information is designed on physical game tokens it can be accessed in any manner the user wishes. AR can add value by applying the principle of hyperlinks on physical objects that leads to display relevant information on physical objects without the need for searching.

2.7 Chapter Summary
In this chapter I have described the development of AR as a field and discussed real-world examples and referenced popular culture. It can be said that AR has potential applications in various fields, but it has not yet matured in a medium for everyday use despite the efforts over the last two decades. I discussed the possible cause of this – the dominance of technical factors in the development of AR, and I concluded that discussion by highlighting the need for design-based research in the field. Then, I described the literature review conducted in specific fields of SAR and AR for user performance, and AR for board games. SAR has more potential in adding value to information support for specific
tasks over HMD-based AR or handheld-AR. The attempts at implementing AR for board games are mostly focused in integrating AR in gameplay. These facts place this research in the specific area of task support using AR in a case of board games. I have then presented the review of the official tutorial and learning aids for the board game chosen for this research and I discussed the limitations of these aids. This sets the ground for the next chapter where I discuss the methodology that I have followed in order to conduct this research.
Chapter 3
Research Questions and Methodology

Overview
This chapter introduces the central questions that have guided this research. There are three research questions, which were treated as separate fields of inquiry. I describe how each component utilises a separate method to generate new knowledge. I begin with data collection that has been inspired by ethnographic methods, analysis of the data using Activity Theory and Research through Design as a method for designing and developing a software prototype. Each research question is elaborated in their separate sections in this chapter where each of the three methods used are introduced. These three methods are elaborated on in the following three separate chapters. The chapter ends with a summary of the research outline and methods, and draws the outline for the following three chapters.

3.1 Motivation
The research dealt with multiple issues in real-world board game scenarios, as discussed in Chapter one. When new players are presented with a new board game, they have multiple options available for learning the concepts and basic strategies of a game. The options include the game manual that is included in each game box, resources on the internet, different forms of tutorials such as videos, or learning the rules from a human teacher. The learning aids available to new players are rarely utilised in-situ and it is often the case that new players learn the game by playing with experienced players, as discussed in section 1.3. Thus, an early motivation for this research was to collect data on how board game sessions play out in the real world and to identify what happens when player experience levels differ in order to compile a rich description of the problems in the scenario and inform the design of a prototype. This research aimed to find or construct an appropriate method of
learning the concepts of a new game, so that both experienced and inexperienced players can play at an optimised level of challenge and enjoyment in the very first game.

The second motivation for this research is to lead a design-based investigation into augmented reality. As discussed in Chapter 2, the development history is dominated by technical issues. There are various toolkits available for developing AR that can be used by non-programmers derived from ARToolkit (Kato & Billinghurst, 1999), but these toolkits remain fairly technical. Macintyre et al. (2004) describe Designer’s AR Toolkit (DART) which is aimed at designers, recognising the shifting AR trend from a technology to a medium. This research postulates that an AR system designed for new players can be a valid medium for a tutorial that can assist in-situ game sessions.

### 3.2 Focus of this Research Project

The focus of this research project is to design and develop an AR intervention for a real-world scenario as a learning and support aid that presents complex information to a user in a manner that helps in making decisions and take informed actions. This AR intervention is tested through experiments with players who do not regularly play board games, with Settlers of Catan as a case study.

In this project I started with a regular board game session: a board on the table, four players encircling it. Each player was provided with game tokens and cards to play the game ‘Settlers of Catan’. All the players had different levels of experience with the board game.

The new player was enabled with Augmented Reality technology and could interact with the physical cards and the board to bring up information and strategic advice whenever required. When the player pointed to a certain region of the board, relevant information was displayed on a tablet screen. When a playing card was put in front of the camera of a mobile phone, relevant information was displayed on the mobile phone screen. Overlay information in the form of text and images was also registered to physical tokens.

New players could refer to information as much as they liked and whenever they liked. This enabled new players to understand the game rules and concepts at their own pace. The system also provided suggestions on the interactive overlay such as strategic advice. The strategic advice provided new players with a good strategic start and in doing so aimed to democratise the game between new and experienced players.
In this scenario, there was information available to new players that could motivate them to consider options and make decisions. Augmented information provided supported new players set clear goals, and provided strategic advice to reach these goals. The system developed in this research project was imagined to free experienced players from the task of teaching the game rules and concepts to the new players, and therefore compete with the new players without special consideration towards their inexperience. The new player was empowered with relevant information and strategic advice and the challenge for experienced players was aimed to remain high, giving all players to experience flow in the very first game session.

3.3 Research Questions
Three main questions directed the progression of this research. The questions are concerned with the shape and nature of an AR intervention, and the interaction of the physical and virtual components of the setup.

1. How can AR support new players to learn the game in-situ when player experience levels are different?

2. How can information be presented to support the understanding of basic game concepts and strategies?

3. How can the AR intervention be designed to make it interactive but non-intrusive to gameplay?

3.4 Methodology
This research structure consisted of four parts: data collection, interpretation, contribution and validation. Data collection and interpretation addresses the first two research questions by employing Ethnography and Activity Theory. The research questions are brought together and addressed in the contribution section by employing Research Through Design methodology.
3.4.1 Data Collection
Data was collected from real world game sessions. The data collection method was inspired by Ethnography, the research method about social interactions between people as they happen in the local context. Ethnography it is about developing “rich” descriptions of events (Fetterman, 2010). The Ethnographic method of participant observations and audio recordings was used in this research project to obtain a better understanding of the challenges that people face when playing board games. The participant observation study was conducted over a period of 6 months, to find out how new players learn a new board game, how experienced players perform the task of teaching the game rules and strategies to new players, and the role of the game manual and other tutorial options.

The data collection project was conducted in accordance to RMIT University Design and Social Context Collage Human Ethics Advisory Network, Sub-committee of the RMIT Human Research Ethics Committee. The project was classified as “Low Risk” and the ethics committee approval is attached in Appendix I.

The data collection project was conducted through participant observation at an informal fortnightly gathering of board game enthusiasts. Posing as a participant, I was involved in all the board game sessions documented for this research. I acted in three roles: as a new player, as an intermediate player, and as an expert. As a new player I participated in game sessions where I was not familiar with the game. In my role as intermediate player I played games that I played before. As expert, I played games that I had lots of experience with. I also explained the game rules to new players and provided them with advice during the game sessions. During this timeframe I collected notes after each game session and photographs that were taken during the game session.

Data was collected from the 11 game sessions which were documented in detail, and there are on average, 30 observations from each game session. The total of 334 observations develop a rich description of the board gaming sessions. This work enabled the development of the problem statement and the development of the scope of this research project.

The descriptions resulting from the data collection project are documented in detail in the next chapter, and in Appendix IV.

3.4.2 Interpretation
The data collection project resulted in a considerable amount of data. Activity Theory was employed as a language during the analysis to describe the data. Activity theory is a theoretical framework for
analysing human practices as developmental process with both individual and social levels interlinked at the same time (Kuutti, 1996). Engeström’s (1999) activity theory triangle model was used as the basic framework for analysis. The basic unit of analysis in the model is an ‘activity.’ The model helps understand the relationship between the subjects and the motive of their actions, as well as components and their relationships in an ‘activity system’ that consists of more than one individual.

Definition and Principles of Activity Theory

“Activity theory is an approach in psychology and other social sciences that aims to understand individual human beings, as well as the social entities they compose, in their natural everyday life circumstances, through an analysis of the genesis, structure, and processes of their activities” (Nardi and Kaptelenin, 2009).

In activity theory people act with tools and technology. Thus any learning aid is seen as a tool that mediates the player’s interaction with the game. The mediation should be designed and used in the context of people with intentions and goals. Players act as subjects in the scenario, constructing their intentions and goals as objects. There are two fundamental assumptions that underpin activity theory:

1. Knowledge is mediated through tools and artefacts, and
2. The basic unit of analysis is an activity.

The principles of activity theory (Nardi and Kaptelenin 2009):

1. an emphasis on human intentionality
2. the asymmetry of people and things
3. the importance of human development
4. the idea of culture and society as shaping human activity

Figure 24 shows how Activity Theory adds value to interaction design by expanding the scope through a cyclical process.
Key Concepts of Activity Theory

The concepts presented here are from the source *Acting with Technology: Activity Theory and Interaction Design* by Victor Kaptelenin and Bonnie A. Nardi (2009). Each concept is defined and elaborated on to demonstrate how they helped define the components and goals of using an AR system for Settlers of Catan.

- **Activity** is the basic *unit of analysis* providing a way to understand both subjects and objects, an understanding that cannot be achieved by focusing on the subject or the object separately. The ‘moves’ of the players form the basic unit of activity in a board game. Each action thus is seen as an activity performed by the subject, the player, using directed towards achieving an objective. Activities, or their components, actions can act as a filter for thinking. If there are multiple options a player is considering before making her move, the making of the move suggests cognition towards a decision. This can help in determining the effectiveness of AR intervention. Actions influenced by the technological aid will be easier to identify in evaluation of the intervention.

- “**Agency,**” the ability to act in the sense of *producing effects,* is a fundamental attribute of both the subject and the object. This is understood in terms of the moves produced by a player on the board game. When a new player is learning a new board game, the agency does not rest with the new player alone. She is acting on information derived from the understanding of the game concepts from a tutorial, or by direct intervention of the human
teacher. Agency, the ability to produce effects is also used to inform the design of information on the AR interface. The information displayed to the player has to consider this notion, which can help the information to be actionable.

- **Natural Psychological Functions (NPF):** Natural functions can develop as a result of maturation, practice, or imitation, but their structure does not change and these functions are basically the same in similar species. The NPFs in a board game relate to the motivations to play the game. Some people play for enjoyment, some play to win. These motivations remain across different board games.

- **Higher Psychological Functions (HPF):** HPFs can emerge as a result of a restructuring of NPFs in a cultural environment. These influence the behaviour of the players in the context of board games. Players have to be sensitive of external factors like rules of the game, and the motives of other players that are involved in playing the game.

- The concept of psychological functions, NPFs and HPFs was also used in context of the range of the consequences of the actions. HPFs are restructured, sometimes multiple NPFs in a cultural environment. The range of the consequences of the actions is broadly either short-term or long-term. Short term actions, or tactics, are actions taken in response to an immediate change of events, or for execution of long-term actions. A long-term action, or strategy, serves a larger goal. For instance, winning the game requires a successful pursuit of a strategy, whereas a response to random game factors is often done by tactics. In both these instances, the mediating tools are quite different. Short-term tools like hammers have a direct impact on the physical world, and are often “invisible” in use. Long-term tools, like maps, need prior learning of some concepts before the tool can be used effectively. AR can act as both these types of tools, it can act as a short-term tool for quick reference of information, and as a long-term tool to explore strategies on the game map.

- **Internalisation** – Subjects who used external meditational artefact’s (tools) to solve a task stopped using the artefacts spontaneously with improved performance. This is the phenomenon of internalisation: the transition of an external operation into an internal one. This is a central of the AR system (the meditational tool) designed for this research: to provide information to the new player in a manner that the players can internalize the information and stop using the AR system with improved performance. This is achieved through the visual overlay approach of AR, as shall be discussed later.

Internalisation is perhaps the most important input of this theory on this component of the research. According to Activity Theory, “in the process of transitioning from an external operation to an internal one, external processes can take place in the internal plane, ‘in the head’. The processes
remain to be mediated, but by internal rather than external signs. Internalisation is not a translation of initially external processes into a pre-existing internal plane, the internal plane itself is created through internalisation” (Nardi & Kaptelenin, 2009). Using Augmented Reality technology, specifically the visual overlay approach, the external operations are visually highlighted. For instance, visual overlay on the Settlers of Catan game map can give information about desirable regions and less desirable regions. This can be accomplished by using suitable 3D augmented objects that are registered to the physical map. The information from the augmented objects can be “seen” without the augmentation after the external processes translate into an internal plane. This example is for the game map laid out because the connections are more explicit. The process of translation from external signs migrating into internal signs that mediate the activities can also be applied to complex notions in “Settlers of Catan like getting the largest army, or the longest road points.

Nardi and Kaptelenin (2009) provide an apt example: “For instance, consider a person driving a car who initially relies on a map but eventually learns the map and gets by without it. The means of carrying out the navigation task undergoes a significant transformation: from relying on an external artefact to relying on an internalised representation.” Similarly, a player using the AR system will initially rely on the information on the system to understand concepts and make decisions, but eventually the person will learn to get by without the help of the AR system. Thus, an important design criterion of the system is that the system is designed for declining usage. It can be said that when the user stops using the AR system and performs actions that demonstrate that the system information has been useful, the AR intervention has been successful.

In order to achieve a declining need for new players to use the AR intervention, the design considerations were derived from the basic principles of graphic design (John, 2014), being part of visual communications. In particular, the methods of proximity, similarity, and repetition were used to design the information layouts that acted as AR overlays. “Proximity” is seen as a sense of distance between elements in a layout. In this case AR content being registered to patterns in the game cards and game map, proximity was naturally at play. The positioning of design of pieces of information was informed by the type of information: mostly it consisted of a few words and some graphics. This content was designed with good visual balance, and at a proximal distance from the actual physical target. “Similarity” was achieved through the use of the same font and graphics across the multiple AR system overlays. In addition, the graphics that were used were scanned copies of the actual game itself, and wherever applicable, the graphics were the same size as the physical game cards, in order to preserve the similarity and continuity between not just the different parts of the AR system, but the physical cards and digital overlays as well. And lastly, “repetition”
was employed in a similar manner by making the graphics look the same so that it is easy for new players to memorise them. Furthermore, the same methods were used for the 3D content as well: the 3D objects used for highlighting various regions on the map were similar in size, colour and animation effects.

The guiding research question for this phase was: How can information be presented to support the understanding of basic game concepts and strategies? This meant considering the rules of the game, and their understanding by the new player within the social framework of a game session.

Mwanza (2001) provides a procedure for analysing work practices in an organisation for the purpose of informing the design to support these work practice. This procedure was used to analyse game sessions with the purpose of informing the design of the AR intervention to support the new player.

The procedure consists of the following six stages (Mwanza, 2001):

1. Model the situation being examined
2. Produce an Activity System of the situation
3. Decompose the situation’s Activity System
4. Generate questions
5. Conduct a detailed investigation
6. Interpret findings.

This procedure was modified to suit the research needs at that stage. A detailed description of how Activity Theory used to interpret data from the ethnographic study is presented in Chapter 5. The interpretation of the data further informed the design of the software prototype, giving detailed instructions to start development.

3.4.3 Research through Design

Research through design is a component of design research (Frayling, 1993), described as a systematic inquiry, which generates communicable knowledge through the practical act of designing (Downton, 2003). This research has generated knowledge through the act of designing and developing a software prototype using the board game ‘Settlers of Catan’ in the scenario described in Chapter 1.

There are two design processes being described here. The first is the design process for doing research through design that has generated knowledge, and the second is the design process of the software prototype, a major component of this research.
Using design as a tool for investigation, the contribution made by this research is through the development of a software prototype system. Research through design was the core research method to progress knowledge in the area of using Augmented Reality as a medium to support new players to learn a new game. As a designer, I have engaged in the process of designing the software prototype being embedded in the process of its creation. At each step in the design process I have attempted to predict future functionalities of the AR prototype and sought to undertake the necessary methods and means to achieve those functionalities. Even as functionalities of the software prototype has largely been dictated by the technical factors, I have had to take several thought-excursions into finding out more about particular technical features so that they can be incorporated into the development of the prototype. The focus during these thought-excursions has been on the counterfactual and the not-yet-manifest states of the shape and the function of the prototype. Through these explorations, new ideas that make certain features possible have been brought into the prototype, often into the design process itself for future iterations.

In the chosen scenario, new players are dependent on information for basic game actions and game strategy on the manual, or on experienced players they play with. However, as the game manual is rarely used, new players are more dependent for information on the experienced players. Through AR as a technological intervention, information regarding game actions and basic strategy becomes more accessible which may lead to the democratisation of the game.

The design process that this research employed used existing special and general knowledge to produce collective knowledge through the development of the software prototype and through the writing of this exegesis. The knowledge generated is embodied in both the processes of design themselves. The knowledge produced by this research is documented in this exegesis for storage and transmission with the goal that this design knowledge will lead to the creation of more design knowledge.

Works of design once made manifest in the world become a means of transmitting knowledge to others (Downton, 2003). The software prototype and this exegesis reveal the knowledge, embodied in the outcomes of inquiring, involved in their making – they are the carriers of knowledge generated through this research. While these works of design are not the only means for knowledge transmittal, they are central to communicating about this research as they embody and convey much of the knowledge produced in the inquiry conducted through designing.
My focus as a designer was on a tangible outcome as a work of design. As a designer, I have learnt through the experience of designing, by engaging in the practical act of making the software prototype. Knowing is in the doing of the designer (Schön, 1984).

The design process followed an iterative decision sequence of problem, analysis, synthesis, and evaluation (Lawson, 1997), which consisted of six steps for every iteration of the prototype. A total of five iterations were conducted in order to reach the final prototype. The actual number of iterations was not defined at the beginning of the development process. Each iteration demonstrates the developmental stages of this research, as well as the concerns, goals and thinking process that are described in this exegesis. The new knowledge is generated through the observations and reflections achieved in the writing of this exegesis.

3.5 Evaluation and Validation through Testing with Users
This section describes the process of data collection during the evaluation of the software prototype. The design of the software prototype is validated by conducting testing sessions with users. The tests consisted of multiple game sessions with the users. The goal was to evaluate the user interface for the system, as well as the user experience. Testing with users was crucial to gain more insights about the intended practical use of the software prototype. This helped test the factors of the software prototype concerned with the research goals in an efficient manner.

Pilot tests were conducted during the development of the prototype as well. These tests are not included in the data analysed for validation, but are used during the design phase, within the five iterations to make changes or adding new features to the prototype developed in this research project: ‘Catan-QuickStartAR.’

Final tests were conducted after the 5th and final iteration of the design and development process. The analysis of the data gathered from these tests is presented in Chapter 7: Findings and Conclusions in section 4 Findings. Chapter 7 also documents the testing procedure in detail. The data analysis is summarised in Chapter 7, while all the data gathered in the all the test sessions is documented in Appendix IV.

The software prototype was informed by comments during demonstrations at the International Conference for Mixed and Augmented Reality (ISMAR), the leading academic conference in the field, and at RMIT University’s Research Symposium (PRS). The first iteration was demonstrated at the PRS in June 2013 and this informed the development of subsequent iterations. The fourth iteration was
demonstrated at the International Symposium of Mixed and Augmented Reality (ISMAR, 2013) in October 2013. ‘Catan-QuickStartAR’ received largely positive reviews from experts in the field.

3.6 Summary
This chapter explained the motivation of this research project, discussed the questions and explained the research methodology. The research was motivated by a real-world board game scenario. Design Research was used, specifically research through design was described as the central method used for this research to progress knowledge. The research was validated at two points using the institutional method of peer review through demonstrating the software prototype developed for this research: ‘Catan-QuickStartAR’. The following chapters describe the three methods, Ethnography, Activity Theory, and Design research in detail, in that order.
Chapter 4
Data Collection

Overview
This chapter discusses the results of the data collection phase inspired by the ethnographic investigation methods. It begins by presenting the research considerations to provide a framework for the discussion on the results. Next, I present the process of data collection in detail. In the subsequent section I provide the results and analysis. The chapter concludes with the formulation of design guidelines for the development for ‘Catan-QuickStartAR’.

4.1 Research Considerations
The research question that guided this phase of the research was:

- How can AR support new players to learn the game in-situ when player experience levels are different?

To answer this research question I needed to investigate (i) what constitutes a good board game session, and (ii) how players learn a new board game.

This stage of the research project determined the role of technology in general game sessions. There can be many forms of technological interventions. Using modern hardware and software, experiments have been conducted with the aim making board games more immersive through the use of visual effects as one form of technological intervention (Molla & Lepetit, 2010; Magerkurth et al., 2004; Andersan et al., 2004; Nguyen et al., 2009; Szalavari et al., 1998; Bjork et al., 2001). For example, (Molla & Lepetit, 2010) replace the pawns of the game with augmented content like animated characters.
Using technology to help players track the game state could be another form of technological intervention. Technology can be used to track various elements of a game like the moves of the opponents’ history to predict their moves, etc. At the time of this research project, there was little research available on this topic. The form of intervention that was chosen for this research was to use AR technology in the form of an enhanced tutorial for new players.

Next, there was the motivation to gain insight into what constitutes a good game session. Several factors were observed that included the design of games, player interactions, and the importance of winning. The design of games included observing game factors guided by Klutz’s Book of Classic Board Games (Sackson, 1990), like the complexity of the gameplay, ease of setup, number of players, random elements, strategic elements, the time it takes to play the game and the enjoyment the game can offer. Player interactions were also observed, how often players have to interact with other players and with the game, and what levels of interaction players enjoyed in a game. The importance of winning was investigated, as an indicator for a good game session for a player.

This research needed to investigate how new players learn a new board game. This emerged as a crucial bottleneck for player involvement with board games as a recreational activity. New players have the option of reading the game manual, do background work before playing their first new game, learn from experienced players on the table, or learn the game through trial and error.

4.2 Data Collection Process – Participant Observation Method

The data collection process was informed by the participant observation study method. Board game sessions are usually conducted in people’s homes, with friends or family who engage in board games. Sessions are also conducted in public spaces where board game enthusiasts get together and play board games. The public setting usually involves multiple board games being played, and people interact with people they do not know. In contrast to home sessions, public sessions offer two advantages: the scale of the activity (there are more games being played at the same time), and more diversity in terms of social factors (different games, different levels of experience and enthusiasm.) The major part of this research was conducted at public sessions because they afforded a better opportunity to study the various ways in which board game sessions play out and were more accessible than private sessions.
To find public game sessions, an online search was conducted. Meetup (2014) revealed a board game group called “Eurogames at The Royal Standard” that met up every second Wednesday at a local pub called ‘The Royal Standard’ which was located at 333 William St in West Melbourne. The group was an informal gathering of board game enthusiasts and new players were always welcome. People brought their board games and placed them on a table near the entrance of the hall, as shown in Figure 25. There was no formal scheduling of players and games. Sessions were conducted on the fly when there was someone willing to teach a new game to new players, or experienced players who wanted to play their favourite game again. This resulted in a dynamic mix of different people playing with and against people with different levels of knowledge about the game. The demographic of the players in regards to their age and gender, nationality, familiarity and interest in board games were very mixed and thus any particular day offered a unique set of board game sessions. This group provided the rich, social environment where the data was collected for this study.

Figure 25: Eurogames at The Royal Standard, where the participant observation study was conducted

The goal of this study was to gather data on how new players learn and play in a natural ‘in the wild’ setting. I therefore used the tool of participant observations with audio recordings and occasional photographs as my primary method of data collection to document game sessions. I have not used
other methods like field notes, video recording and interviews in a conscious effort from my side not to disrupt a game session. It was not appropriate to use video as a documenting method because privacy concerns that people may have, and also because of the fact that people’s behaviour may change. I also did not want to make the players feel uncomfortable as this may have affected their behaviour during the game sessions. Whilst video would have provided a wealth of data about the game sessions, particularly the behavioural and personality cues of players, those were outside the scope of this research.

Similarly, the collection of data via field notes was a difficult method to execute. As I was an active participant in the board game sessions, I had to play the game in a sincere manner. Therefore, it would have been inappropriate for me to take notes during a game session, as this would have potentially disengaged me from the social activity, paused my involvement, and drawn the attention of other player’s to my process of note taking. However, there are always crucial moments in each game session which are particularly useful for research, and to mark them I took photographs. After each game session I transcribed the audio recording and used the photographs to remember the key moments in which I had made an observation.

4.2.1 Documenting a Game Session
In total I collected data from 11 board game sessions amounting to 334 raw observations from which key observations are derived for insights. All 11 records of the game sessions are presented in Appendix II. Figure 27 shows an example of one of the observations of a single game session.

<table>
<thead>
<tr>
<th>Game: FLASH POINT: FIRE RESCUE Designed by Kevin Lanzing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Six players, clockwise from me: Me, B, S, B2, M, and N. B is explaining the game.</td>
</tr>
<tr>
<td>2. He is speaking too fast and the rules are many.</td>
</tr>
<tr>
<td>3. Only B knows the game, rest all are new players.</td>
</tr>
<tr>
<td>4. B is very enthusiastic about explaining the rules.</td>
</tr>
<tr>
<td>5. The game has lots of tokens: fire, smoke, black cubes, dice, ambulances, player fire fighter figures, as seen in Figure 26.</td>
</tr>
</tbody>
</table>
6. B is explaining everything in a random manner, it is difficult to associate the tokens with their actions.
7. B is playing a new version of the game, so is not sure about some new features.
8. There are several fire-fighter roles - each player picks up a role card and a corresponding figure to play with on the board.
9. M goes for blue colour, says it is her favourite.
10. Players spend time guessing which role corresponds to which figure.
11. “It does not really matter,” B says, “Each figure gets a coloured base as well, so that helps.”
12. B has a favourite fireman he wants to play with.
13. Explains damage cubes, if all the damage cubes are on the walls, we immediately lose the game, the building falls down. This is how we lost the first game and new players did not really pick up on this fact. It did not come across as something important.

Observation: As a new player it is difficult to differentiate between game critical information and the game play information.

14. Explains fire-markers. The way fire appears: there is a smoke. Says if we have to add smoke to the board and there already is smoke, it turns into fire.

Observation: Does not explain how and why and where fire starts.

15. Links between fire and smoke and walls explained. It is not clear to me, but B goes on to explain “doors” in the building.

Observation: There is no time to interrupt his explanation to ask any questions.
16. Doors disappear when there are explosions in the building, doors are the first ones to go. But they absorb a bit of the explosion before they go.

Observation: ABRUPT INTRODUCTION TO THE CONCEPT OF EXPLOSIONS. DIFFICULT TO LINK THE CONCEPTS TOGETHER.

17. We were playing the harder version of the game, with only two doors in and out of the building. So there are multiple versions, I wonder why we are playing the harder version with so many new players.

18. Concept of chopping through the walls to get to another room, - but you add damage cubes to the building!

19. Mentions that this will hasten the building collapse, but it is necessary sometimes and thus has to be done.

20. There are Hazmat materials on the board as well, if that gets hit by the fire there is an explosion. But there are hazmat technicians. We can carry these materials off the board as well.

Observation: TOO MANY NEW CONCEPTS!! DIFFICULT TO FORM LINKS BETWEEN THEM.

21. Paramedics can heal people. There are some healing tokens that help move victims faster.

22. There are fifteen people tokens: 5 blank and 10 people and pets.

23. There is a discussion about one pet token: squirrel or a meerkat or something.

24. Interruption - S hovers around, player R was looking for a way out. They swap seats.

25. S is now playing - he is not familiar with the game as well.

26. B explains about rescuing people, taking them “there” after ambulance action, if they die, they go “there.”

27. As soon as we have 7 people there we have won, and as soon as we have 4 people there we have lost.

28. Thus there are two ways to lose the game: building collapses if all damage tokens are on the map, or 4 people die in the fire. Only one way to win: 7 people safe.

29. Did I mention? This is a cooperative game, so people have to play with each other as a team, and not compete with each other. This was my first cooperative game.

30. Playing on medium difficulty level because lower difficulty is way too easy.

31. B says that’s all for the rules and we are starting the game.

32. Then he rolls the dice multiple times and places fire and smoke tokens on the map.

Observation: THE GAME SETUP IS STILL GOING ON, AND IT FEELS UNFAIR TO NOT START THE GAME AFTER THAT LONG A RULES EXPLAINING SESSION.

33. B places explosions and fire. There are “hotspots” on the map where a fire starts. If there is no fire, only a smoke token appears.

34. Everyone is patiently listening. I am not sure if B is explaining the game still or has the game already begun.

35. The second explosion! Walls with one damage cube cannot be walked through. Only walls with two damage cubes can be walked through.
36. So that is the start of the game!

**Observation:** FINALLY! WE GET TO PLAY!

37. “There are also these materials someone left behind; we do that by rolling the dice again.”

**Observation:** WHAT NOW?!

38. The materials behave exactly like people when you have to drag them out.
39. Explains about the engine spraying water on a quarter of the board, but you can only do it if there are no fire-fighters standing in that space. Takes the entire turn to play it unless you have the deck gun specialist.
40. Mentions that you can change roles now.

**Observation:** WAS NOT CLEAR UNTIL IT OCCURRED IN THE GAME THAT YOU CANNOT SPRAY WATER ON THE WHOLE QUARTER, YOU ONLY CHOOSE A QUARTER AND THEN ROLL THE DICE.

41. Mentions the starting position. Says you can enter through doors, but you can also smash a wall to make a new entrance, perfectly legitimate.

**Observation:** B WAS JOKING BUT IT WAS DIFFICULT TO PICK IT UP. SEEMED LIKE GOOD ADVICE.

42. B mentions his tactic ... other players did not understand.
43. Explaining action points now. About moving around on the fire engine, and changing roles and firing the deck gun.
44. Each turn has 4 action points + more if your special character has more.
46. M recaps her fire-fighter abilities when it is her turn.
47. N reviews all actions available on her turn.

**Observation:** PLAYERS ARE CLARIFYING THEIR DOUBTS ONLY WHEN THEIR TURN COMES, THEY DO NOT INTERRUPT BEFORE IN THE TUTORIAL.

48. I do the same because I feel comfortable about asking questions at that point.

**Observation:** PLAYERS FEEL IT IS OK TO ASK QUESTIONS AND HALT THE GAME ON THEIR TURN AND NOT ON OTHER TURNS.

49. B explains a lot but says “I'll let you do what you want.” The danger of cooperative games is that one guy becomes the alpha male and dictates actions to other players.
50. It is up to you, play the game, enjoy the game.
51. First role is an explosion.
Observation: STILL EXPLAINING THE RULES - NOW ABOUT FIRE PROGRESSION.

52. More explosions - hard game is a good game B says.
53. More fire, more explosions. This might be over quickly.
54. B explains something about the small arrows on the board.

Observation: IT IS DIFFICULT TO PAY ATTENTION TO NEW FACTS BEING EXPLAINED WHEN YOU ARE TRYING TO PLAY THE GAME. I WASN’T PAYING ATTENTION AS I FELT LIKE I COULDN’T UNDERSTAND EVEN ONE SENTENCE MORE.

55. Game moves on, more explosions and walls damaged.
56. Players are still clarifying their doubts.

Observation: B TRIES TO GIVE “GOOD ADVICE” WHICH IS SOMETIMES CONTRARY TO THE DECISION THAT THE NEW PLAYER HAS COME AT.

57. M is trying to think for others, suggesting actions.
58. The game is looking bleak, by many explosions and fire.
59. N uses the deck gun option, but was not clear on the use of it. She thought the deck gun can be used on the whole quadrant.

Observation: IF THE PLAYER EXPLAINING THE GAME MAKES AN ERROR, PLAYERS CAN BE UNINTERESTED IN THE GAME WHEN THEIR ASSUMPTIONS ARE WRONGED.

60. I am not sure about my actions options and try to involve people in my turn.
61. One more, last explosion and all damage tokens are on the map: the building has collapsed and we all have died. B: I was hoping to end this game quickly because our luck was very bad. M: Maybe we should think about who we are and rethink who we want to be.
Discussion on the roles of different players.

4.3 Analysis - Insights and Inferences

Players with different experience levels often play against each other. These are the different roles with their informal titles. I arrived at these categories through observations:

1. The First Timer – a player who has come to such a gathering for the first time. The player is a bit conscious, and takes a little while to get used to the first game being played, as well as the social environment. Once the player starts playing the game, concerns regarding the
social environment fade away and the focus is on the task at hand. After the game, the player may or may not return to another public game session.

2. The Novice – a player who has attended one or more sessions before, but does not regularly engage in playing board games.

3. The Enthusiast – a player who tries to regularly attend such sessions. This kind of player is likely to engage in sessions outside of the public game session as well i.e. at home with friends and family.

4. The Hard-core Gamer – a player who plays a board game with deep attention and focus. The aim is to have a deeply strategic game.

5. The Teacher – a player who is familiar with the game being played, and is enthusiastic about teaching the game to new players. There may be some players who are hard-core gamers as well as teachers, but this is not necessarily the case.

Ethnography involves lengthy textual analysis after data collection to produce insights, this was not conducted as the goal of using an ethnography inspired method was to obtain key insights from the board game sessions, and formulate design considerations for the proposed AR system.

Insights were derived from key observations (written in block letters in the sample game documentation presented). Next follows a discussion on how the key game observations led to insights. For this game there were fifteen observations. Table 1 illustrates this process:

<table>
<thead>
<tr>
<th>No</th>
<th>Observation</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>As a new player it is difficult to differentiate between game critical information and the general gameplay information.</td>
<td>Better presentation of the game rules helps new players learn what is most important.</td>
</tr>
<tr>
<td>2</td>
<td>There is not time to interrupt his explanation and ask any questions.</td>
<td>The speed of the tutorial needs to consider new player’s concerns about some topics.</td>
</tr>
<tr>
<td>3</td>
<td>Abrupt introduction to the concept of explosions. Difficult to link the concepts together.</td>
<td>The concepts presented together need a hierarchy or progression, and better presentation of the game rules helps new players learn what is most important.</td>
</tr>
<tr>
<td>4</td>
<td>Too many concepts! Difficult to form links between them.</td>
<td>Better game presentation required, in addition to better presentation of the game rules helps new players learn what is most important; and the concepts presented together need a hierarchy or progression.</td>
</tr>
<tr>
<td>5</td>
<td>The game setup is still going on, and it feels unfair to not start the game after that long a rules explaining session.</td>
<td>New players just want to start playing the game.</td>
</tr>
</tbody>
</table>
Finally! We get to play!

New players just want to start playing the game.

What now?!

New players become restless if the tutorial is too long.

Wasn’t clear till it occurred in the game that you cannot spray water on the whole quarter, you only chose a quarter and roll the dice.

Some rules need to be better explained, and better presentation of the game rules helps new players learn what is most important.

B was joking but it was difficult to pick it up. Seemed like good advice.

The concepts presented together need a hierarchy or progression, and better presentation of the game rules helps new players learn what is most important.

Players are clarifying their doubts only when their turn comes, they do not interrupt before in the tutorial.

Players feel comfortable with asking questions in their turn.

Players feel it is OK to ask questions and halt the game on their turn and not on other turns.

Players feel comfortable with asking questions in their turn.

Still explaining the rules – now about fire progression.

New players become restless if the tutorial is too long.

It is difficult to pay attention to new facts being explained when you are trying to play the game. I was not paying attention as I felt like I couldn’t understand even one sentence more.

Game tutorial and the following game play should not overlap too much.

B tries to give ‘good advice’ which is sometimes contrary to the decision that the new player has come at.

The teacher needs to be sensitive to player’s decisions, and needs a better narrative.

If the player explaining the game makes an error, players can be uninterested in the game when their assumptions are wronged.

The teacher needs to be sensitive to player’s decisions, and needs a better narrative.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Finally! We get to play!</td>
</tr>
<tr>
<td>7</td>
<td>What now?!</td>
</tr>
<tr>
<td>8</td>
<td>Wasn’t clear till it occurred in the game that you cannot spray water on the whole quarter, you only chose a quarter and roll the dice.</td>
</tr>
<tr>
<td>9</td>
<td>B was joking but it was difficult to pick it up. Seemed like good advice.</td>
</tr>
<tr>
<td>10</td>
<td>Players are clarifying their doubts only when their turn comes, they do not interrupt before in the tutorial.</td>
</tr>
<tr>
<td>11</td>
<td>Players feel it is OK to ask questions and halt the game on their turn and not on other turns.</td>
</tr>
<tr>
<td>12</td>
<td>Still explaining the rules – now about fire progression.</td>
</tr>
<tr>
<td>13</td>
<td>It is difficult to pay attention to new facts being explained when you are trying to play the game. I was not paying attention as I felt like I couldn’t understand even one sentence more.</td>
</tr>
<tr>
<td>14</td>
<td>B tries to give ‘good advice’ which is sometimes contrary to the decision that the new player has come at.</td>
</tr>
<tr>
<td>15</td>
<td>If the player explaining the game makes an error, players can be uninterested in the game when their assumptions are wronged.</td>
</tr>
</tbody>
</table>

Table 1: Observations and Interpretation

The various interpretations derived from the observations of this game are documented in Appendix II. The interpretations highlight the following concerns regarding the importance of: the design and presentation of game tutorial; sensitivity towards the new player’s learning capacities; the control new players have on the structure of the game tutorial; and the motivation of new players to “just start” of playing the game and learning the rules in-situ. From these observations, a total of four key observations in the context of how new players learn a new game, were found to be recurring, as shown in Table 2:
<table>
<thead>
<tr>
<th>No</th>
<th>Key Observation</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The manual was not referred to by any of the new players.</td>
<td>New players do not learn a new game from the manual.</td>
</tr>
<tr>
<td>2</td>
<td>Everyone waited patiently while B recalled the rules.</td>
<td>New players prefer to learn the game rules from an experienced player than the manual.</td>
</tr>
<tr>
<td>3</td>
<td>Everyone is getting tired of the rules, and wants to start the game.</td>
<td>New players prefer to learn the rules while playing the game.</td>
</tr>
<tr>
<td>4</td>
<td>Strategic games present a dilemma to the teacher.</td>
<td>New players should receive strategic advice from a difference source than the teacher.</td>
</tr>
</tbody>
</table>

Table 2: Key observations and Interpretation

The last key observation on the table requires longer description, because similar situation was recurring in all board game sessions. An acute problem arose when new players were learning the game from a human teacher. As the game begun and the new player had to make strategic decisions, new players would ask for strategic advice which placed the experienced players at a dilemma. The more the experienced player explained and suggested moves for the new players, the more they sabotaged their own strategy. Moreover, the game became more predictable, and therefore less interesting. The game was regarded as a “learning session” for the new players and the experienced players had to invest about two hours on a game without having an optimal experience, and there was no guarantee that the new players would play the game again.

It is unlikely that any of the players experienced Flow. Flow is defined as an experience “so gratifying that people are willing to do it for its own sake, with little concern for what they will get out of it” (Csikszentmihalyi, 1990). The optimal game experience is not often achieved by new players. New players are concerned with learning of the concepts of the game and acting on them. Game manuals are rarely referred to by new players, and the assistant apps are not very useful because they take too long to complete and are optimised for only a single linear game experience.

The interpretations derived from the game sessions generate the inferences shown in Table 3. The complete list can be found in Appendix II.
**Table 3: Interpretation and Inferences**

<table>
<thead>
<tr>
<th>No</th>
<th>Interpretation</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New players are not concerned with winning the game.</td>
<td>Importance of winning for new players is low.</td>
</tr>
<tr>
<td>2</td>
<td>“Trading” happens often, and players learn the importance of resources in this interaction.</td>
<td>New players enjoy games that require players to interact more.</td>
</tr>
<tr>
<td>3</td>
<td>New players prefer simple games.</td>
<td>Games with low complexity get better reception from new players.</td>
</tr>
<tr>
<td>4</td>
<td>New players can learn complex games if the narrative of the tutorial is right.</td>
<td>With the correct tutorials, complexity of the game can be high.</td>
</tr>
<tr>
<td>5</td>
<td>New players like the dice element in games.</td>
<td>The random element is an important factor for player enjoyment.</td>
</tr>
<tr>
<td>6</td>
<td>New players can strategize in their first game.</td>
<td>The strategic thinking component should be in good balance with the random element.</td>
</tr>
<tr>
<td>7</td>
<td>New players are concerned about the time it will take for them to play the game.</td>
<td>New players enjoy that are reasonably timed.</td>
</tr>
</tbody>
</table>

**4.4 Results**

A number of observations during the ethnography inspired study point to the problems new players face when learning a new game. The process of learning the basic rules and formulating a basic strategy are crucial factors which affect the outcome of the game session. Learning the rules and basic game concepts can be done through reading the manual, or by referring to online resources. In practice, it was observed that the manual or the online resources are almost never used by new players. Instead, it was observed that in most cases new players prefer to learn the game by asking experienced players, and preferring learning as the game progresses.

This indicated that AR intervention designed to help new players at the beginning of the game adds most value in the scenario. If the new players can learn the rules without asking experienced players, they can learn at their own pace, and experienced players can concentrate on the game. This information needs to be provided directly on game cards and the game map to eliminate the
searching required in the case of using a manual or other resource like information on the internet. Thus following key guidelines were derived from these observations:

- Intervention during the beginning of a game adds value.
- Provide basic information on game cards
- Provide move options on the game map that helps with making a strategy.

To achieve this aim, information regarding game rules was provided on game cards and game map so that it was easily accessible for new players. To help new players make a basic strategy - information was provided by visually displaying move options on the map. This was done using the visual overlays, an inherent feature of Augmented Reality applications.

The larger concern of this research was to democratise the game by providing timely information to new players which empowers them to make their own decisions and act on them. The democratisation was envisaged to decrease the dependency that new players have on experienced players in their first game and as a result increase challenge for experienced players and decrease the difficulty of the new players. Thus the following guidelines were also noted for the design of the AR software prototype ‘Catan-QuickStartAR’, which was developed for this research:

- Democratise the game by providing relevant information to new players.
- Increase the level of challenge that experienced players play at by empowering new players with information.

Choosing Settlers of Catan

Based on inferences derived from interpretations, I chose to work on the German board game, Settlers of Catan (SoC). SoC features a highly interactive gameplay. It is reasonably simple to learn. Observations in ‘the field’ suggest that with a well-designed tutorial, new players can understand and act on complex strategies. In SoC, on the one hand it is possible to execute very complex strategies, and on the other, the random element of the dice plays can play an important role. The unique game mechanics: consists of simple elements that can be grasped easily, at the same time presents potential for complex strategies made by the interrelationships between the game elements that can be executed after multiple game experiences. Moreover, SoC is considered to be a good entry level game to introduce players to board gaming as a recreational activity (Starlit Citadel, 2014). The game won multiple awards, including the prestigious Game of the Year Award in 1995 (Spiel des Jahres, 1995). About 20 million copies of Catan have been sold worldwide and Catan is regarded as “The Board Game of Our Time” (Eskin, 2010).
The game elements like the game cards and particularly the game map lend themselves to AR. The game map is randomised in each game, and holds numerous manifestations of games through different strategies. Moreover, the game difficulty was also a major factor in the decision for choosing this game. Catan is initially quite hard to learn and that is why it is a better choice than simple games like Trouble, but it is not as complex as other games like Twilight Imperium. A normal “Settlers of Catan” session takes about 60 minutes of game play, with new players it can take about 90 minutes, which is a reasonable length in comparison to other games.

Catan also has the optimum number of players, according to the data from (Board Game Geek, 2014) an online board games discussion and information portal. There are player-number-specific lists of ‘Top Games for 2 Players’, and ‘Top Games for 3 Players’, and so on. There is also a general list for ‘Top 100 Board Games’ which is more comprehensive as it considers all factors that make up a good game, not just the number of players. Table 4 shows the relationship between the two types of lists: in column 1 it lists the ranks of top three games on player-number-specific list and its mathematical average in column 2. This mathematical rank can be considered as the average tank of 2, 3, 4, 5, or 6 player games in the list of Top 100 games. The average rank of 2-player games is 16.6, average rank of 5-player games is 28.3 and of 6-player games is 45.6, whereas for 3-player and 4-player games is only 5.0 and 4.6 respectively. This shows that 3-player and 4-player games are most popular among all board games. The basic version of Settlers of Catan, which has been used for this research, can be played with three and four players. Thus makes it a suitable game from the factor of the number of players required to play the game.

<table>
<thead>
<tr>
<th></th>
<th>Ranks of Top 3 games in Top 100</th>
<th>Average Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Player Games</td>
<td>1, 21, 28</td>
<td>16.6</td>
</tr>
<tr>
<td>3 Player Games</td>
<td>2, 3, 10</td>
<td>5.0</td>
</tr>
<tr>
<td>4 Player Games</td>
<td>2, 4, 8</td>
<td>4.6</td>
</tr>
<tr>
<td>5 Player Games</td>
<td>22, 24, 39</td>
<td>28.3</td>
</tr>
<tr>
<td>6 Player Games</td>
<td>33, 48, 56</td>
<td>45.6</td>
</tr>
</tbody>
</table>

Table 4: No of players and Board Game Popularity
4.5 Summary

The data collection phase revealed information about board game sessions as a richly social activity. The revealing observations into player types, and their motivations to play were presented. In-game observations led to insights and inferences on player interaction, failures in the practical use of game manuals and other tutorials. The data generated guidelines for the AR system that was designed for this research. The scope for technological intervention using AR was determined to be at the start of the game. The board game ‘Settlers of Catan’ was chosen for prototyping.

The data collection phase revealed information about board game sessions as a richly social activity. The important observations made were that new players face a set of issues in learning a new game, and the learning aids such as the manual and other references on the internet are rarely utilised in practice. In-game observations led to insights and inferences on player interaction, failures in the use of game manuals and other tutorials. In summary, they key insights are:

- New players do not learn a new game from the manual.
- New players prefer to learn the game rules from experienced players.
- New players prefer to learn the rules while playing the game.
- New players should receive strategic advice from a different source than an experienced player.

This defined the scope for the AR intervention and thus the AR system designed for this research to the start of the game, and to democratise the game by providing basic game information and strategic advice to new players. In addition, it was observed experienced players should be free from the task of teaching the game to new players so that they may play their normal game. The board game ‘Settlers of Catan’ was chosen for prototyping, and the basic guidelines were formulated in order to begin the design of the AR software prototype, they are:

- Intervention during the beginning of a game adds value.
- Provide basic information on game cards
- Provide move options on the game map that helps with making a strategy.
- Democratise the game by providing relevant information to new players.
- Increase the level of challenge that experienced players play at by empowering new players with information.
Chapter 5
Data Interpretation – Activity Theory

Overview
The previous chapter described how the board game ‘Settlers of Catan’ served as a model for the research and explained the use of an ethnography inspired study conducted for this research. This chapter presents how the Activity Theory framework was used to conduct a detailed analysis of the ‘Settlers of Catan’ board game. The chapter begins with a description of the role of current psychological frameworks in research and lists the key components of the theory being employed for the research. Activity Theory was used to analyse the ‘Settlers of Catan’. A 6-step procedure based on Activity Theory, designed by Mwanza (2001), was used to interpret the findings of the data collected through the ethnographic observations. The results yield a seven-point outline that informed the development of the AR prototype for ‘Settlers of Catan’.

5.1 Introduction
This chapter shows how Activity Theory was used to analyse the components involved in Settlers of Catan, while considering an AR-based support system. This addressed the second research question:

- How can information be presented to support the understanding of basic game concepts and strategies?

The purpose of this approach was to make explicit the different ideas and concepts involved in the design of the software prototype. AR was cast the role of a tool that was being used by the subject, a new player, to achieve certain objectives. The actions that the subject performed through the mediation of AR as a tool were outlined.
This chapter uses the Second Generation Activity Theory, using Mwanza’s (2001) procedure to apply the model in the current context of the board game Settlers of Catan.

5.2 Need for a Theoretical Framework

In order to analyse the game, ‘Settlers of Catan’ a theoretical framework was used to explore the game components of the game and the relationships between them.

This chapter presents a logically structured representation of the concepts, variables, and relationships involved in analysing ‘Settlers of Catan’ as a social activity. To this purpose I identify what will be explored for an AR based intervention.

Shneiderman (2003) identified five types of roles and uses of theories:

1. **Descriptive** theories identify key concepts or variables and make basic conceptual distinctions
2. **Explanatory** theories reveal relationships and processes
3. **Predictive** theories make it possible to make predictions about performance in a range of contexts
4. **Prescriptive** theories provide guidelines based on best practice
5. **Generative** theories facilitate creativity, invention and discovery.

To determine how AR can add value in board game sessions, the theory was required to be descriptive, identifying the key concepts of the board game ‘Settlers of Catan’ and the enabling variables of AR technology. Conceptual relationships and distinctions between these two domains of concepts needed to be described in order to gain clarification about the role and scope of AR intervention. The theory had to be explanatory, revealing relationships between the concepts and processes, including the process of game play as well as AR interaction. The theory also had to be prescriptive, generating guidelines for the next stage of prototype development.

There are three domains of information that are discussed. First is the board game ‘Settlers of Catan’, as a system of rules and components that interact with each other. The second is Augmented Reality, the technology that is the topic of research. The third is the theoretical framework that introduces concepts that link up the components between the first two domains.
5.3 Activity Theory Models

This section presents all three models of Activity Theory that have evolved in the last century briefly and mentions the model used for this research.

The model in Figure 28 is derived from Activity Theory developed in the 1920s and 1930s by Vygotsky (1962), when studies were focused on individuals. Vygotsky proposes that tools, artefacts, symbols and instruments mediate between the subject and the object. The subject refers to the actor in the activity being analysed and the object is the objective she is trying to achieve here. This relationship is depicted in the simple triangle in the illustration. This is called the first-generation activity theory model. This does not take into account what happens to activity systems with more than one individual.

![Figure 28: The First Generation Activity Theory Model: Vygotsky’s Model of Mediated Action](image)

The second generation model builds on the first generation activity system model (Figure 29). This model was proposed by Engeström (1987) as he argues that “the focus of the study of mediation through tools and instruments should be on its relationship with the other components of an Activity System,” as seen in Figure 29. It introduces three new factors to the activity system that are concerned with collective activities: Rules, Community and Division of Labour. The first factor relates an ‘activity’ to a set of rules that are implicit or explicit and influence the manner in which the activity occurs. The second factor is about a ‘community’ of actors that collectively influence a group of activities but not individual activities. The third factor addresses the ‘division of labour’, particularly on how the labour in the activity is broken up.
There is a third generation Activity Theory Model, based on the notion of two activity systems interacting, but this research uses the second generation model.

**5.4 Using the Activity Theory Model for Settlers of Catan and AR**

Daisy Mwanza (2001) provides a procedure for operationalising activity theory using Engeström’s second generation activity triangle model. The procedure was developed for analysing work practices of an organisation to inform the design of a computer system to support the work practices. This procedure is used in this research for analysing the components of a Settlers of Catan game with the same goal in mind: to inform the design of a software prototype. The procedure consists of the following stages:

1. Model the situation being examined.
This stage follows the eight-step model to identify the following:

a. The Activity of interest: a board game with players with different experience levels.
b. Object of the activity: all players want to experience an optimal balance of enjoyment and challenge.
c. Subjects in this activity: new players and experienced players at a board game.
d. Tools mediating the activity: the physical game tokens and cards, learning tools like the game manual.
e. Rules and regulations mediating the activity: board game etiquette, observe the rules of the game.
f. Division of labour mediating the activity: in the general game session, there is an expert player who teaches the game to new players, there is a person managing the “bank” of resources in the game.
g. Community in which the activity is conducted: the activity is carried out as part of recreational board gaming.
h. Desired outcome of the activity: similar to (b.) all players involved want to experience an optimal balance of enjoyment and challenge.

2. Produce an Activity System of the Situation being investigated.

The answers derived from the 8-step model informed the making of Engeström’s Activity Model (Figure 31) for board games. The subject of the model is the game itself, the collective consensus of all the players involved, and their object is to have a good game. The concept of Flow (Csikszentmihalyi, 1990) helps define such a game: A game session can be considered as a rewarding experience for both the new players and experienced players when both face optimal levels of challenge against each other and enjoyment with each other. The model generated is shown in Figure 30:
The model was also generated from the user's perspective (Figure 31), when the user is considered as the subject, and the AR system that is being designed to help her, is being designed for this research.
This approach helped identify areas to be derived from the ethnographic investigation to give the design of the software prototype a detailed outline.

3. Decompose the situation’s Activity Systems.
   a. **Decomposition of the First Activity System (Figure 30):** The subject of the activity here is the board game being played, and the object is to have a good game. A good game, defined in the previous step, for new and experienced players means that both the sets of players should experience an optimal amount of challenge and enjoyment. For the new players, they should understand and grasp the basic information for playing the game, as well as the complex information that is required to form strategies. For the experienced players, the level of challenge should remain high as if they are playing against experienced players and not new players. This will ensure that the experienced players don’t have to play below their strategic level.

   b. The mediating tools and instruments are now classified into two types: conceptual tools and physical tools. The conceptual mediators for the game are the strategies and tactics employed in playing the game. The physical mediators include the cards and the game tokens through which the game is being played. The conceptual tools for learning are game experience and the general attention and cognition during the game. The physical mediators for learning are the manual and other sources of learning (i.e. internet or game-assistant apps)

   c. The Rules of the activity system are the rules of the game, along with physical rules like board games etiquette and reasonable human manners.

   d. The Community includes all the players involved in the particular board game.
e. The Division of Labour can be seen as either horizontal or vertical. Vertical division refers to the different experience levels of the game i.e. experienced players often have to explain the nuances of certain game components. Horizontal division arises during the gameplay, as players use and exchange game tokens.

a. **Decomposition of the Second Activity System (Figure 31):** the subject of the activity is the new player and his objective to obtain information from the AR system to play the game.

b. The mediating instrument or the tool here is the AR system itself. The subject has to understand two types of objects: physical objects to play the game with, and the digital objects that illustrate certain concepts of the game.

c. The Rules of the game guide all the actions of the game session (along with general physical rules of playing a board game with other players), and the rules of using the AR system. This requires that the rules for using the AR system must be as simple as possible.

d. The Community remains the same: all the players of the particular game.

e. The Division of Labour can be seen as the division of information the subject obtains from the mediating tool: the AR system. The information has to be concisely presented and clearly divided into manageable portions.

4. Generate Research Questions. This stage does not apply to this research as the research questions have already been generated and AR is being used in a specific scenario. Thus, this
stage can be used to Develop Guidelines for the Design of the AR System, which are presented in the next section.

5. **Conduct a Detailed Investigation.** This stage did not apply, as the detailed investigation was conducted as part of data collection process inspired by ethnography prior to this exercise.

   It must be noted that this 6-step procedure is not the primary methodology employed for this research. Prior to this process, research questions had been generated and the ethnography inspired data collection study had also been conducted in the chosen scenario at the appropriate location. The analysis of the data generated by the study gave the broad guidelines for the scope of an AR intervention for board games, and helped choose a particular board game for this research, namely ‘Settlers of Catan.’ Board games can be complex activities by themselves. The addition of an AR system in the chosen scenario of in-situ game support to new players was a more complex task. To aid the research at this point, Activity Theory was employed through Mwanza’s 6-step procedure. Thus steps 4 and 5 had been established prior to applying this procedure.

6. **Interpret Findings.** This findings derived from the analysis of the two Activity System Models, and the application of key concepts from AT on Settlers of Catan in section 3.4.2, gave rise to design considerations for the AR system developed. They built upon the design guidelines presented the previous chapter.

The outline consisted of two parts. Firstly, the shape of the information presented through the AR system and its scope and role, and the shape of the system itself. The information presented had to be contextual in nature, pertaining to physical cards and map regions. This would support in the process of internalisation, as discussed in section 3.4.2 Key Concepts of Activity Theory. Moreover, the information presented should be easy to refer to and grasp, there are two concerns here: the design of the information and AR overlay layouts and the technical factors like recognition of physical targets from the real world. Finally, all the information provided to new players through the system had to be enough for the new players to feel confident in their game actions. On the other hand, the information should help new players make a basic strategy, as this was a most crucial point of games here the objectives of new and experienced players differ. The new players want to learn a game, but they are dependent on experienced players to teach them the game rules and help to develop a strategy to win the game, but the more help the experience players provide, the less
enjoyable the game becomes. Thus if the AR system provides information on making a basic strategy, it could enable experienced players to play a normal game. And finally, the interaction that the new player has with the AR system should not be complex, as the new player is already concerned with learning a new game. This could be achieved by making the overlays easy to access and technical process of recognising the physical targets as easy as possible by considering technical guidelines. The interaction of the new player must be minimal, to the point that the experienced players are not aware of the new players using such a system.

This discussion presented the considerations that led to the development of seven clear guidelines for the design of the AR system:

1. The AR system has to be easy to learn and to use.
2. The system should provide contextual information.
3. The system should structure information in a way that is easy to refer to and to understand by the player.
4. The AR system should provide the new player with all the basic information.
5. The AR system should provide the new player with information that enables the player to make informed strategic decisions.
6. The AR system should reduce the reliance on the experienced players so that they can concentrate on their own part in the game.
7. The AR system should be non-intrusive to other players.

5.5 Conclusions
The use of Activity Theory key concepts has given broader meaning to the components involved in the research. It has made explicit many ideas concerning the game Settlers of Catan and the technology used for intervention, Augmented Reality. Activity Theory has provided an external language of description that has moved the analysis beyond the description level, it has revealed the rich and deep meaning behind the motives of the research. It has provided an outline for the development of the AR intervention for Settlers of Catan. In the next chapter, this outline is used to design and develop the software prototype titled ‘Catan-QuickStartAR.’
Chapter 6
Research through Design

Overview

The chapter describes how this research project used a research through design methodology to progress knowledge. This chapter describes in detail the design of an AR software prototype for the game Settlers of Catan. It also describes the development environment and defines the technical terms. The prototype underwent five design iterations. The concerns and the design process for each iteration are described in detail in the following sections. The chapter ends with a summary of the design process, iterations and knowledge generated.

6.1 Research through Design

“Designers make propositions about the way something could be, their propositions incorporate speculations about desired ways things will work and look, they want to know what will transform the existing into the desired, they want to find the ways and means to achieve the desired.” (Downton, 2003)

The development of the AR system was heavily guided by what is technically possible. Nevertheless, I kept in mind at all stages the broader context of its role in an everyday life scenario (Dunne, 1999). In each step of the design process I endeavoured to predict both the future state of the prototype and the necessary methods and means to achieve those states. Each future state was intended to overcome the design and technical problems in the current state; analysing these problems helped determine the methods needed to implement the necessary changes. However, the shape of the software prototype was largely dictated by the technical factors rather than design factors. I undertook several ‘thought excursions’ to learn more about specific technical features from a design
point of view. Through these explorations, new ideas that make certain features possible were brought into the prototype.

All the incremental design decisions made in the development of the software prototypes were propositions that could be tested. Many were tested in the process of their making, and I evaluated the functionality of each iteration of the software prototype once it was completed. I obtained feedback during a demonstration of the software prototype’s features to an expert panel at RMIT University’s Practice Research Symposium, and to the audience of the International Symposium on Mixed and Augmented Reality 2013 (ISMAR), the leading academic conference in the field of Augmented Reality. The insights gathered on analysing the feedback at the end of each iteration informed the design for the next iteration. Many insights facilitated decisions about whether to pursue a proposition any further, or the different ways in which propositions could be modified.

Design knowledge generated through this research includes knowledge from three fields. First, I generated knowledge from my investigations of board games. I collected a wealth of data using participant observations in real-world settings. Second, the design concerns generated with AR were used as a medium of information, specifically for designing complex information layouts. Thirdly, I generated knowledge regarding the innovative use of technical features, specifically the occlusion-based triggers that enable navigation through information layouts.

6.2 The Design Process for the Software Prototype
The design of the system, which included hardware and software components, is discussed here. The AR software prototype system, henceforth referred to as ‘Catan-QuickStartAR’, underwent five design iterations. The number of design iterations required to achieve a workable prototype was not predetermined, but it was assumed that the design process would go through at least three iterations before achieving the functionality required for validation through testing with users. The design method I followed in this research project was a hybrid industrial product design process, with parts of the process appropriated from design processes from other fields. Figure 32 depicts the design process.
I present a general discussion on each step of the process here, and in the next section I present a detailed discussion for each of the five iterations of this design process that were undertaken to develop the final version of ‘Catan-QuickStartAR’.

6.2.1 Define Problems
The first step for each iteration was to define the problems in a way that was conducive to identify solutions in the different areas. Problem setting was a process in which the problems that needed to be addressed were interactively framed and contextualised (Schön, 1983). The definitions of the problems set the direction of all subsequent steps of that particular iteration of the design process.
6.2.2 Generate Ideas

The second step required the generation of ideas. As I carried out the task of defining the components of the problem for each iteration, specific areas for the generation of ideas were broadly separated into design ideas and technical ideas. I attempted to develop options for each and every component of the problems. Multiple options were essential to allow me to weigh up the candidates before execution. The step was thus not ‘free brainstorming’ of ideas but structured brainstorming, along with developing concepts.

“A great deal of everyday designing involves drawing. This drawing may be done with a computer or a pencil – the concern here is with the process, the interaction between the ongoing making of a representation and the evolving knowing of the designer making the representation.” (Downton, 2003)

I did a tremendous amount of work during the design and development of the software prototype, as the pages of my notebook show (selected pages are presented in Appendix III). Downton’s word ‘drawing’ here represents the many ways in which I distilled the raw ideas from thinking into actionable instructions, lists, reference illustrations and wireframes. Some notebook pages (presented below) illustrate this process at specific points. The nature of this intermediate process that Downton calls ‘drawing’ means it is hard to form a coherent narrative from them; therefore, it is difficult to represent this process of drawing in the writing of this exegesis. Nevertheless, I must state that these drawings embody the essence of the design process that my research followed. It would be wrong to concentrate on the outcomes of this research, namely the software prototype and this exegesis; they represent the finalised states of the research undertaken and the attempt to communicate it. The drawings through which my inquiry was undertaken represent the personal journey of exploration that I employed (Downton, 2003), thus they reveal more about research through design than the final outcomes. Figures 33 and 34 show the drawings from the first iteration.
Figure 33: Notebook drawings for ideas before first iteration (1)
Figure 34: Notebook drawings for ideas before first iteration (2)
6.3.3 Design
The third step was to gather the software and hardware to design solutions for the problems. At this stage the multiple ideas generated to target each specific component of the problem had been tested against each other, and generally a few ideas per component had been selected. I collected the necessary materials for addressing the issues (problem components) and made concrete plans for specific actions.

6.3.4 Develop
The fourth step was development. As a major part of this research was software coding, the ideas had to be translated into the appropriate form so I could work on them in the integrated development environment. The software used for coding was the popular game engine Unity 3D (Unity, 2014). Unity3D offers a 3D modelling, animation and rendering environment for development of games and other software projects in 3D. It supports integration of thousands of ‘assets’—software components that are added to projects as and when required. For instance, if the developer is creating a 3D landscape, he can integrate a ‘trees pack’ from the asset store. This enables developers to add tree structures without having to model trees themselves.

The computer vision algorithms were sourced from Qualcomm’s Vuforia SDK. Vuforia is essentially a library of algorithms that enables developers to develop AR applications. Vuforia contains features called ‘prefabs’ that can be attached to the projects which enable AR. I employed three crucial prefabs in this project, detailed below:

1. To enable vision-based system input, the ‘ARCamera’ prefab can be attached to a project using the development environment’s GUI. Adding this prefab enables a project to take camera input from any available camera like a webcam attached to the computer, or any mobile camera device that the project is deployed on.

2. To enable trackability, the ‘imagetarget’ prefab allows the user to overlay a Qualcomm-certified image file that the developer wishes to track in the real world.

*Markerless Tracking and Marker-based Tracking*

In the early days of AR when computer processing was much slower than today, algorithms were used to track simple physical markers. Algorithms were also unsophisticated, meaning they could only identify geometric patterns with a high level of contrast. Thus a library of
fiducial markers has to be standardised to work with the algorithms. Image 35 shows fiducial markers and markers displaying AR content.

(a) Examples of Fiducial Markers

(b) Augmented Objects on Fiducial Markers
(Image (c) m_nukui, Flickr)

Figure 35: Fiducial Markers

Typically, the algorithms work on these markers by identifying geometric patterns like circles, edges or curves. As technology progressed on both the hardware and software fronts, more sophisticated algorithms could compute a greater amount of markers within the same amount of time. In parallel, the cameras available in mass markets became capable of capturing higher-resolution images. Thus, markerless image recognition became possible. Markerless tracking still tracks markers, but they are defined by the user, and can consist of any image with sufficient detail. This expanded the range of AR applications. Now the number of physical markers was not constrained to the markers library any more, and it was possible to track millions and millions of physical images with sufficient detail. At present constraints like the level of detail and contrast on the markers have to be considered while
developing applications, but as technology continues to progress, physical images and objects with everyday lighting conditions will be able to be tracked more efficiently.

Qualcomm’s Vuforia developer portal features in the development loop. To make an image target work, Vuforia must have a set of xml values about the image. This is achieved by selecting the image file to be tracked in the physical world and uploading it to the developer portal. The portal will analyse the file and rate it for ‘trackability’. Files with a high level of detail and contrast are given a 5-star rating of ‘very augmentable’; this means that the image can be tracked in a wider range of physical conditions like lighting, reflection, distortion, distance and occlusions. If the rating is less than five stars, the portal provides suggestions on improving the image by adding more contrast and detail.

As an example, consider the following comparison. The image of Pasture on the Catan game map (figure 36a) and the production centre of the sheep resource, has a low amount of detail. Figure 36 (b) represents how the software would register this image from camera images. This image received three stars out of five for augmentability. Figure 36b contains a low density of yellow crosses, which indicates that the image does not have many features. This will make it more difficult for computer vision algorithms to register and track this image than the next example.

![Figure 36: Pasture/Sheep Hex-tile from Catan Map, (b) with ‘features’](image-url)
The image of Forest on the Catan game map, the production centre of the wood resource, has considerable detail and thus a high density of features (Figure 37 (b)). This image received five stars for augmentability, so will track better in a real-world scenario.

At this point, there are two options for increasing the trackability of the image. The first option is to add more detail by manipulating contrast and colour levels. Image editing software such as Adobe Photoshop has to be used to achieve this. The second option is to change the properties of the physical object itself. For this research, the target image files were the board game cards and map. I worked with existing illustrations. The optimisation, then, was limited to changing the contrast and colour levels of the image files. In some cases I added more detail to physical objects to make them more readable by the software, like the game map in iterations 4 and beyond. After the image has received at least a 3-star trackability rating, the developer has to download the image as a compressed unity package. This package is expanded in Unity3D and the xml file is available for use on ‘imagetargets’. This enables the ‘ARCamera’ prefab to identify and track the ‘imagetarget’ when the program is deployed on mobile devices or run on the computer with a webcam.

3. To enable interaction, the ‘virtual button’ prefab. ‘Virtual buttons’ can only be created on ‘imagetargets’. ‘Virtual buttons’ allow the developer to have certain rectangular ‘hotspot’ areas which trigger events when occluded. For instance, in the Vuforia ‘virtual button’
demonstration, this teapot changes colour when the appropriate ‘virtual button’ is pressed. The events that are triggered have to be written in code. Unity3D uses the Monodevelop (2014) coding environment. Vuforia can integrate both JavaScript as well as C# (C Sharp) programming languages and reference examples on the developer portal are shown in both. Monodevelop can also process both scripts for Unity3D. I worked with C# due to my familiarity with the syntax in earlier projects. The writing of this code for this project and its optimisation accounted for the major portion of the development of the prototype.

6.2.5 Deploy Prototype
The fifth step is deployment. The program code is compiled for errors and executed. The program can be deployed on devices attached to the computer (after the necessary drivers and other tools are installed). For this project, I used an Android phone for iterations 1 and 2. The errors in the code had to be addressed at this point for the program to work as designed.

6.2.6 Refine
The sixth and final step was refinement of the program when it was run in the deployment stage. This step is particularly important for AR projects because the registration of the augmented content is to the physical object in 3D space. In the development simulation the developer has to rely on some guesswork about the position and size of augmented content. In the real world the augmented content can look different than imagined due to a slight offset that arises due to estimated positions. Refinements were effected in the position offset and the lighting and colour of the augmented content. Beyond this point, after each iteration the system was demonstrated to external reviewers.

As noted earlier, the first iteration was demonstrated at RMIT University’s Practice Research Symposium by demonstrating the AR system to a panel of experts. The second and third iterations were informally demonstrated to board game enthusiasts for their feedback. The fourth iteration (again, as noted previously in this chapter) was demonstrated at the International Symposium of Mixed and Augmented Reality (ISMAR, 2013). The fifth and final iteration was evaluated formally with users, the results of which are presented in the following concluding chapter.
6.3 Design Iterations

In the following sections, each design iteration is discussed in detail. Five design iterations were conducted to produce prototypes. An overview of the key advancements over the five iterations is presented in Table 5.

<table>
<thead>
<tr>
<th>Advancements</th>
<th>1st Iteration</th>
<th>2nd Iteration</th>
<th>3rd Iteration</th>
<th>4th Iteration</th>
<th>5th Iteration</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Feature Included</td>
<td></td>
<td>Virtual Buttons</td>
<td>Enlarged Map</td>
<td>Information Design</td>
<td>AR Menu</td>
</tr>
<tr>
<td>Game Cards Augmented</td>
<td>✓</td>
<td>✓</td>
<td>Discontinued</td>
<td>Discontinued</td>
<td>Discontinued</td>
</tr>
<tr>
<td>Phone AR</td>
<td>✓</td>
<td>✓</td>
<td>Discontinued</td>
<td>Discontinued</td>
<td>Discontinued</td>
</tr>
<tr>
<td>Information Content (phone)</td>
<td>Basic</td>
<td>Basic</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Original Map</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Split-System</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Big Map</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Information Content (map)</td>
<td>Strategic</td>
<td>Strategic</td>
<td>Strategic</td>
<td>Tutorial and Strategic</td>
<td>Tutorial and Strategic</td>
</tr>
<tr>
<td>Animation</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Virtual Buttons</td>
<td>-</td>
<td>6 on Ref. Card for Phone AR</td>
<td>9 on Map</td>
<td>29 on Map</td>
<td>60 on Map</td>
</tr>
<tr>
<td>Icons</td>
<td>-</td>
<td>Ref Card</td>
<td>3 on Map</td>
<td>6 on Map</td>
<td>6 on Map Improved</td>
</tr>
<tr>
<td>Portable Camera Mount</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Demonstration/ Evaluation</td>
<td>Peer Review (RMIT PRS)</td>
<td>-</td>
<td>Pilot Tests with Users</td>
<td>Demonstration (ISMAR 2013)</td>
<td>Tests with Users</td>
</tr>
</tbody>
</table>

Table 5: Five Iterations at a Glance
6.3.1 The First Iteration

This section describes the steps taken in the first iteration of the design process. The prototyping environment had been decided at this point. To reiterate briefly, I chose the Unity3D authoring environment because it supports Vuforia SDK (Vuforia, 2014), an advanced set of image recognition libraries for making AR applications. The steps involving the Vuforia portal required registering online as a developer with Qualcomm Vuforia (Developer Vuforia, 2014). Once registered, I could upload my images to the online developer portal and improve the ‘trackability’ of each image based on the suggestions given by the developer portal. I edited images using Adobe Photoshop (Adobe, 2014). Figure 38 gives an overview of the first iteration.

![Figure 38: Design Process: The First Iteration](image)

The design outline

The main goal of the AR system is to provide accessible information to new players in their first game. In section 5.6 I presented a 7-point outline for making the AR intervention accessible to new players, reproduced here for clarity:

1. The AR system has to be easy to learn and to use.
2. The system should provide contextual information.
3. The system should structure information in a way that is easy to refer to and to understand by the player.

4. The AR system should provide the new player with all the basic information.

5. The AR system should provide the new player with information that enables the player to make informed strategic decisions.

6. The AR system should reduce the reliance on the experienced players so that they can concentrate on their own part in the game.

7. The AR system should be non-intrusive to other players.

**Steps of the Design Process**

1. Problems. The AR system must provide basic information so that the new players do not have to refer to the manual or ask experienced players, and it must provide strategic advice to new players so they are not dependent on experienced players to develop a strategy to play the game. Thus, the problem statement was defined as being that the AR system should provide all the basic information about the game components and should help the player construct a basic strategy.

2. Ideas. Generate ideas for the design of appropriate information layouts. List the information for two domains: game cards and the game map. Information for game cards: name, corresponding hexagon production centre, and description similar to what the player would find in the manual. The game map should help the new player differentiate between areas with more and less resource production.

3. Design. Data were gathered from the following sources: the official game manual, as well as the assistant apps, insights from personal experience, and the ethnography inspired data collection process. The task here was to design the information in small units of text so that the text was readable. Taking insight from services like Twitter and mobile short messages (SMS) that have helped standardise the character length of a short message, as a general guide, the additional information was displayed in sentences that consisted of up to 140 characters. Thus the augmentations for the cards were designed to be short and included pictures. Figures 38 and 39 on the previous pages present examples of the design layout drawings generated at this stage.
The very basic map augmented overlay consisted of floating spheres over map nodes. The game map being very richly detailed, I decided to use a very basic 3D shape – the sphere – because it would stand out at first glance. The spheres were coloured and their purpose was to hint at the more desirable and less desirable spots. Red spheres were used to indicate less desirable spots, green spheres for desirable spots. Blue spheres were used for most desirable spots, as the colour blue does not feature in the game map illustrations, and thus stands out the most. The level of desirability was judged by resource variety and the probability count of the numbers making up the node.

4. Development. Firstly, all the game cards were scanned: five resource cards, nine development cards, card backs, the reference card, and the cards for the largest army and longest road. All of the cards images were edited. The files were uploaded to the developer portal and some changes were made as recommended by the portal. An important lesson learnt was that you cannot edit the image file by increasing the colour saturation and contrast indefinitely. The resulting file can have a very high contrast and thus a high augmentation rating, but it would be very different from the actual image, and thus it will not be recognised by the AR system and will not be augmented.

5. Deployment. The program was deployed on an Android device. Google Nexus 4 was used for the development. After installing the necessary drivers, the application was deployed on the Nexus phone.

6. Refinement. Some of the augmentations were edited for information layout. Some sentences were too long and thus difficult to read in the overlay. All of the augmented content had to be calibrated for position. The AR system was demonstrated at the Practice Research Symposium in June 2013 to a panel of experts. The game cards augmentation received unanimous criticism of not being very user-friendly as the text was hard to read—the font was not very clear. The map augmentation was well received, and I was advised to pursue this direction.

6.3.2 The Second Iteration
1. Problems. The following four main problems emerged from the first design iteration of the AR system.
   a. The cards augmentation received criticism as being too text heavy. The information content for the cards was from the game manual. Thus, my goal was to display all
the content, which takes about four pages in the game manual distributed across the cards. The reference card had the largest amount of text.

b. The ergonomic problems involved in using the map needed to be addressed. The map is 10-13 cm from the player at its closest edge and about 50 cm away from the player at the farthest edge. In order to review all the regions of the map, the player had to get up from his or her seat and hold a mobile device over the spot, until the augmentation appeared. If the device moved too quickly, or if the region of the map was not in the camera’s field of view, the augmentation would disappear.

c. In interaction with the regions of the map, other players were disturbed. If the player is intensely surveying one region other players’ attention would naturally be diverted towards that region. This meant the flow of the game was interrupted as the players referred to the map augmentations and the cards augmentations.

These problems pointed towards the need to remove mobile phones from the map interaction process. In addition, the amount of text on the cards had to be reduced. Figure 39 gives an overview of the second iteration.

2. Ideas. This section describes the two main innovations in the use of AR technology in this research. The problems described in section 6.2.1 are addressed by these two ideas.
The ergonomic factors hinted at the trouble with using a mobile device floating in the 3D space over the game board. The long-known technical issues of AR, namely errors in registration and tracking, made it difficult to access augmented information even after the ergonomic problems were overcome. The answer involved separating the camera from the display. I realised that if the camera was mounted at a fixed position with a view of the game board, the registration and tracking issues would instantly be resolved.

As the position of the game board does not change, fixing a camera on top of the game board provided consistent video stream input to the software. This reduced the tracking errors, as the ‘imagetarget’ (the map) only needed to be identified by the software, and as it did not move, the software didn’t have to track it.

The second idea appeared while going through the features of the Vuforia SDK in the documentation. Vuforia has a ‘virtualbutton’ prefab, which when attached to an ‘imagetarget’, allows the developer to trigger conditional actions if the ‘virtualbutton’ area is occluded on the physical ‘imagetarget’. Events as defined by the developer can be triggered when these buttons are occluded. In the context of the project, this gave opportunities to display more text conditionally.

3. Design. The design of information for the map underwent an upgrade because of the change in the enabling AR technology setup. Now, as the map remained fixed in the camera view, it became possible to provide more information than the coloured spheres. As a result, the value of each node was calculated and that number was displayed on the map, instead of the spheres. This was displayed by using another basic shape – a white square – with a number in black, to make the squares as different to the game graphics as possible. The node value is the sum of the number of dots on the game numbers on the three hexes making the node. Higher node value means the node would produce resources consistently.

The game manual suggests new players calculate this prior to the initial settlements phase. If this information is presented to new players in their first game it can help them attain a better position in the game.

This idea addresses an important issue with Settlers of Catan in the initial settlements phase. Imagine being told all the game rules in about ten minutes, and in that state when there is a lot of confusion regarding the new facts and the links between them. Immediately after explaining the rules, the game starts, and the first task is placing the initial settlements. Unarguably, this is the most crucial set of actions that a player takes in the game. The
consequences of picking a less productive node results in a game in which the player does not earn a lot of resources, thus cannot do much. This will affect the new players’ first impression of the game, and they may not be inclined to play again. Clearly, this is a good spot for AR intervention.

The design of reference information involved ‘virtual buttons’. These buttons were initially located on the reference card itself. The problem here was communicating the information about which area was a button. To address this problem, a ‘button pad’ was designed on the back of the reference card. Various layouts for the buttons were tested, first on paper prototypes and some on the actual physical token, as shown in Figure 40. The information was divided into six categories, and written as a text-image texture on a plane that slid into view when the button was ‘pressed’. The plane slid back when the button ceased being pressed.

![Figure 40: Options for Virtualbutton Layouts](image)

Thus, two changes were made to the information relayed to the player: instead of the coloured spheres indicating desirability, now there were number scores displayed, and the reference information was displayed on ‘slides’ controlled with the button pad on the back of the reference card using ‘virtual buttons’.

4. Development. In this iteration the complete map was input as an ‘imagetarget’. In the earlier iteration the map was broken down into components for better performance for tracking, but in this iteration the camera was stable, thus it was possible to work with the whole map file as an ‘imagetarget’. The construction of the map involved ‘stitching’ together the map-
scans from the previous iteration. Text slides were designed in Photoshop and imported as rendering texture materials in Unity. Slides were animated to slide in and out.

5. Deploy. The deployment of this version of the AR prototype required the most amount of work, as many new factors were introduced. The running of the program on a portable display was the main issue. After exploring options, the manner in which the AR system worked was as follows: A suitable webcam (Logitech QuickCam Pro 9000) was mounted on a table on a particular height of 110 cm. The augmented video output was displayed on the computer through the Unity ‘Play’ mode. A screen-sharing program was used to mirror the computer’s screen onto a portable device. The program ‘Team Viewer’ was used on an iPad tablet. Once this was working, checks for latency were performed.

6. Refine. The refinement of the program consisted of animating the augmented node numbers, as they were too static. Higher numbers (representing more desirable nodes) were animated faster as their motion would draw the user’s attention (Cavanagh, 1992). This iteration was demonstrated to peers who were board game enthusiasts for their informal feedback. As noted earlier, the information displayed on the reference card back was criticised heavily. The information access was too complicated and its interaction required substantial learning effort. The reference card was augmented within a certain range, and it was prone to tracking and registration defects. The technical issues hampered smooth interaction: the recognition time of image targets averaged about 1.5 seconds, long enough to break the illusion of a seamless relationship between the elements of the physical world and the digital world. Moreover, the concept of ‘virtual buttons’ was a new interaction style that the players were experiencing for the first time. This meant that while they were trying to learn the concepts of a new system or rules (the board game) they had to learn how to access the information. This type of interaction was deemed to be working poorly as it decreased the speed and efficiency of use of the AR system, and it was logical to terminate this direction.

Moreover, the AR experience consisted of using two devices: the smartphone and the tablet, for the cards and the map overlays respectively. The user had to switch between the two, and this was not very smooth due to technical and usability issues. Using two devices to access information was a cumbersome task. It was assumed that the users would prefer interacting on the tablet, primarily because it has a bigger screen and can easily display more information. The map augmentation was rated as more informative than the first iteration.
Instead of the coloured spheres, the node value numbers gave more information to the user. This direction was pursued further in the next iteration.

6.3.3 The Third Iteration

1. Problems. The primary criticisms of the previous iteration were that the phone AR was difficult to use, and this component of the AR system was discarded in this and following iterations. The map augmentation had scope for adding more information. Thus, for the next iteration, the problem statement became ‘what more information can be displayed to new players through the AR system that will help them learn the game more efficiently?’

2. Ideas. The ideas concerning the features of the software are discussed first, followed by the ideas concerning displaying more information about The Settlers of Catan. Figure 41 presents the notebook page where these ideas were generated.

Figure 41: Notebook drawings for ideas during the third iteration

Now the focus shifted to providing more information to the users on the map. The software had difficulty in recognising the map in ordinary lighting conditions, so it was digitally edited
for higher contrast. The level of detail differed across the regions of the map. In particular, the nodes where three hexagons met had little detail compared to the hexagons themselves. Level of detail was enhanced by adding X-zones—a set of three Xs placed at vertices of a triangle. Figure 42 shows the design process for this iteration, with the image of the game map used in the middle.

The data collection process described in Chapter 4 showed new players struggled with the task of placing the initial two settlements before the start of the game. This is arguably the most crucial action set in a Catan game session. Through AR, if there is an interactive overlay of placement options, new players will be empowered to make the right choices for the first settlement. It will also free the experienced players from the dilemma they face when asked for advice on game strategies.

A popular strategy employed in Settlers of Catan is to go for resource variety. There are five resources in Catan. Each settlement will cover up to three different resources. Because the map is made of hexagons laid out randomly in each game, there are limited options for covering all five resources with the two settlements. Without a healthy flow of all five
Another popular strategy is to go for a good number range. This strategy places a greater value on having a healthy number spread than resource variety. This means players choose locations with six different numbers between their two initial settlements. Resource variety is preferred, but only after the more valued number range is achieved. For instance, 3-6-9 and 4-5-10 is a very good spread, because it covers six out of the 11 possible dice outcomes. A good number range will ensure there is a flow of resources coming in with most of the dice turns. An overlay that displays interactive options for this strategy assists new players in considering this strategy.

In addition to these strategies, information about the node value is always valuable and this overlay from the previous iteration was still useful. The option of highlighting better nodes (with higher values) would help the new players grasp the information faster. Thus, the three overlays that can help the user with the map are overlays with information on these three strategies. To summarise, the ideas generation stage recommended making three interactive overlays for displaying the node value of all nodes with a feature that will highlight the more important nodes; information that will display options for each node for both number-range and resource-variety strategies.

3. Design. The primary challenge for design in this iteration was threefold. Firstly, the overlays had to be designed, then the interaction had to be designed, and finally the map had to be modified to contain suitable graphic hotspots that would act as ‘virtual buttons’. ‘Virtual buttons’ contain the enabling code that will switch between the different overlays.

   a. Design of overlay 1: the number cubes. The number cube is a simple cube-augment that contains a node value. The scale was changed for highlighting better nodes. Better nodes were made bigger to stand out from other nodes. Text had to be used as an image, and augmentation was achieved through using the image as a texture of a 3D augment.

   b. Design of overlays 2 and 3. These overlays had to highlight appropriate nodes with either three resource varieties or three different number ranges. Simple brightly coloured cubes with a basic rotation animation were sufficient to communicate the required information. A torus shape was also tried to maintain the hexagonal shape consistency with the game board tiles.
This phase also involved making a larger map, about 50% bigger than the original map. This was done in Photoshop, and more detail was added to the map as well, by adding the x-zones at node areas, and increasing the general contrast of the map.

Visual languages play an important role in electronically mediated communication, iconography in particular (Innocent, 2006). Suitable icons were designed for the ‘virtual button’ hotspots by keeping in mind the visual style of the game board. These icons would trigger the different overlays.

Lastly, the following ‘intelligence’ module had to be created: the actual node values of each node, and a table of corresponding nodes for each of the two basic strategies.

4. Development. The development phase of this iteration was the longest of all iterations in this project. This was mainly due to the need to familiarise myself with the various concepts of programming. Vuforia has limited reference materials, making it a challenging task to work with the new ‘virtual buttons’ feature. After some exploration, the ‘switch case’ was discovered. The switch case is the software code that switches different states of the program corresponding to the ‘virtual button’ being pressed. This feature was used in code for ‘virtual buttons’ (see Appendix V).

5. Deploy. This stage consisted of compiling the code and running the program. Because of the amount of software code – over 2000 lines – I made many errors in syntax or logic, all of which had to be located and resolved.

6. Refine. I implemented three major refinements for this iteration. Firstly, the game map was much bigger than the original game board, making the game pieces out of proportion. Bigger pieces were made using cardboard and coloured paper. Secondly, the icons designed were too similar, and were hard to read; different styles of the font and layout were tried. Thirdly, the ‘virtual buttons’ had to be resized according to the detail of the game board region where they were located. This allowed the overlays to be triggered as the ‘virtual buttons’ were pressed consistently. This iteration was also demonstrated to peers who were board game enthusiasts. Their first criticism was that the game map now had too much information, and interaction was confusing. Second, the interaction was quite problematic, as any movement over the board triggered different overlays. The decision was made to take out the two overlays displaying resource variety and number range, and keep only the overlay for the node values.
6.3.4 The Fourth Iteration

1. Problems. The previous iteration attempted to provide strategic information to the new player. The primary problems were too much information for the user, and the information access was complicated because of the interaction. Moreover, much of the basic information about the game cards and resources was not available to the player.

2. Ideas. The task was to find a way to display the basic information about the game, which was the missing module in the previous iteration. Now this information had to be displayed without a smartphone, as the use of the smartphone was discontinued after the second iteration. It was clear that this had to be done somehow on the map itself. So, with more space to work with to display reference information, the concern was to structure this information in a manner that was easy to understand. There was an opportunity to design a narrative for this information: some overlays before the others, as some concepts had to be known before understanding others. The notebook page illustrates the ideas generated (Figure 43).

Figure 43: Notebook drawings for ideas during the fourth iteration
3. Design. Given the ideas described above, the challenge was to design all the information a player needs to know in a particular order. Taking inspiration from the manual, the information was designed about Resources and Cards, Nodes, Earning, Trading, and Strategic advice for the second settlement, in that order.
   a. The Resources and Cards overlay had the information about all the hexagon tiles on the game board (resource-producing regions) with their relevant resource name and resource card.
   b. The Nodes overlay gave basic information about the nodes, like rules for building and the node values.
   c. The Earning overlay showed—through examples—how players acquire different resources on rolls of the dice.
   d. The Trading overlay gave basic information about trading, such as trading with the bank or with other players, and also helped players to understand the ports trading concept by allowing them to find out more about a port by clicking on any port.
   e. The Strategic Advice layer gave the users information about the options for building the second settlement with respect to the resources covered by their first settlement.

4. Develop. At this point I encountered a major problem with the text and its readability at this magnified level. The Unity 3D text did not scale well: the text behaved as a raster image and was pixelated at larger sizes. To resolve this problem, a very long method had to be used: text was written in different 3D modelling software, exported as a .3ds file and imported as a 3D object in Unity. This process consumed a lot of time, but was the only way in which readable text with a sharp font could be used. Figure 44 gives an overview of the fourth iteration.
5. **Deploy.** The initial deployment of this code was not working, and therefore separate programs were used to display all the required information on the AR system.

6. **Refine.** The refinement stage for this design iteration involved working with the camera for input. It ran on a table with a frame built on it in my lab, which made it impossible to carry to another place, as required so I could demonstrate it at ISMAR 2013 (the premier conference in the field of Augmented Reality, held at the University of South Australia, Adelaide). Therefore, I constructed a mobile Camera mount from a lampshade. This required recalibration of quite a few augmentations, like the number squares, so that the augmented information could be displayed correctly. (On demonstration of this iteration at ISMAR 2013, Roy Ashok, the project leader for Vuforia at Qualcomm, was delighted at the use of “so many virtual buttons!” in the strategic advice overlay. He mentioned that they had been unsure how this feature would be used by the designers in the real world.) The AR system featured in the eight highest-ranked demos (out of 27) at the conference, and was runner-up for the AR user experience category (Figure 55, p. 113). Despite the good reviews, the program demonstration was far from smooth. I had to switch between different programs, and this disrupted the flow if a new player was using the system in an actual game. The icons
used for the different overlays also received criticism for not being clear, and for not representing their layers. General improvements were required in the code as well.

6.3.5 The Fifth Iteration

1. Problems. As mentioned in the last section, the primary problem with the fourth iteration was the lack of cohesiveness in the program’s features. The code was split into different programs, and for demonstration I had to switch between them. This had to be optimised. The code itself was too complex; it was a result of integrating small improvements to each feature and included a lot of experimentation (cut and paste, commented-out patches). This also was to be refined. The last problem was the visual style of the ‘virtual button’ icons; it was too similar to the game graphics style. The icons had to be redesigned to stand out and provide affordance to the user for interaction (Norman, 1988). Figure 45 gives an overview of the rest of the steps of the fifth iteration.

2. Ideas. A menu structure had to be designed for better navigation of information. All the different overlays should be triggered from one parent overlay; this interaction had to be redesigned, starting from the icons used. Icons emerged as an important component of user interface design in the evaluation of the previous iteration. Interactivity makes an icon an active agent in communication rather than a passive communicator (Innocent, 2006). In the augmented information, the first Resources overlay showed the resource card for all the production hexagons; it was too much information as it covered the entire board, and there was a lot of repeating information. Cards can be conditionally triggered as and when the user points to a hexagon. In the Nodes second overlay, basic information about nodes was required, with the node values and highlights. The third Earning layer, needed to contain a few examples of nodes, illustrating how they produce resources. The fourth Trading layer needed no improvements. The fifth layer, Strategy Advice, had to give information about the second node to acquire depending on the resource variety strategy.
3. Design. I designed the icons with a minimalist inverted colours theme. The design of information on each overlay used the principles of graphic design, including the balance, proximity, alignment, repetition and contrast (John, 2014).

BALANCE - Balance provides stability and structure to a design, the weight distributed in the design by the placement of your elements.

PROXIMITY - Proximity creates relationship between elements. Elements placed near each other suggest a connection between them.

ALIGNMENT - Allows us to create order and organisation. Aligning elements allows them to create a visual connection with each other.

REPETITION - Repetition strengthens a design by tying together individual elements. It helps to create association and consistency. Repetition can create rhythm (a feeling of organised movement).
CONTRAST - Contrast is the juxtaposition of opposing elements (opposite colours on the colour wheel, or value light / dark, or direction - horizontal / vertical). Contrast allows us to emphasize or highlight key elements in your design. (J6Design, 2014)

4. Development. The development of this iteration was made possible through the Unity feature of ‘scenes’– software programs that can be switched from one to the other if they are part of the same project. I developed five scenes, one for each overlay, and a master scene that allowed switching between these scenes. This structure also helped reduce the false triggers of unintentional ‘virtual button’ presses. This was made possible by using only a ‘back’ button for each overlay to return to the main menu, thus the other ‘virtual buttons’ were inactive in one particular overlay. Scenes helped me write the code efficiently, as well as the interaction. Figure 46 shows a screenshot from the Earning overlay on the game map.

![Figure 46: Overlay 3 “Earning” on ‘Catan-QuickStartAR’](image)

5. Deploy. This step consisted of building the scene library for the program and running the scene that housed the main menu.

6. Refine. As in previous processes, the sizes of ‘virtual buttons’ had to be refined for smooth interaction and to make them more robust to lighting conditions.
6.4 Chapter Summary

This chapter described how I conducted research through design. I presented the design process followed for the development of the software prototype. Each of the seven steps of the design process for all five iterations was presented in detail. To summarise, each iteration included at least one new feature. The first iteration was deployed on the phone, and all the information from the manual on game cards, along with strategic advice for the map. In the second iteration, a stationary camera was mounted on top of the board to minimise AR errors and help the new player access information in a more ergonomic manner than using a phone to survey the map. Empowered by the stationary camera, the third iteration aimed to provide a large amount of strategic advice, but the resulting prototype was too complicated to interact and was terminated. In the fourth iteration, information design issues were tackled to present an AR tutorial on the map with contextual information. The fifth iteration features an AR menu for better interactivity. At this point, a satisfactory performance of the AR system as guided by the design outline presented in the previous chapter was achieved. The AR system was tested with users and the findings are described in the next chapter.
Chapter 7
Findings and Conclusions

Overview
“Design is a speculative proposition susceptible to testing. It has the characteristic of an
experiment: the design ideas can be evaluated by their originator or by others.” (Downton,
2003)

This chapter describes the evaluation conducted with the fifth iteration of the software prototype
and its findings. The chapter ends with a summary of the research and its contributions.

7.1 Testing with Users
The testing procedure consisted of fifteen game sessions. Twelve sessions involved a test subjects
who do not regularly play board games. Two games were played with each test subject, one with
‘Catan-QuickStartAR’ and one without. Three sessions involved test subjects who are board game
enthusiasts, and after the demonstration of ‘Catan-QuickStartAR’ I conducted an interview to gather
their feedback. Sample test documentation is presented next for one of the sessions involving a test
subject who does not regularly play board games. The documentation for all sessions, including the
pilot session and the interviews, is documented in Appendix IV.

7.1.1 Research Questions and Experimental Design
To recap, the research questions I was trying to answer were as follows:

- How can an AR system support new players to learn the game in-situ when player
  experience levels with the game are different?
• How can information be presented to support the understanding of basic game concepts and strategies?
• How can the AR intervention be designed to make it interactive but non-intrusive to the gameplay?

The tests with users were conducted with one new user (empowered by ‘Catan-QuickStartAR’) playing against experienced players. The information presented to the new player was refined through the five design iterations described in the previous chapter. To measure retention of information, the players were asked to play a second game. This game was played without any help from ‘Catan-QuickStartAR’, and the player actions were recorded for analysis. Specifically, the game involved placement of the first then second settlements, formulation of a basic strategy, choosing the expansion steps correctly, and playing with reasonable speed. The player actions in settlement placements were documented through photographs. A summarised discussion of the evidence of formulation of a basic strategy, aided by analysis of expansion steps, presented in the Findings section that follows. The analysis is documented in full for each player in Appendix IV.

7.1.2 Testing Procedure

There is less known about software testing than about any other aspect of software development (Myers et al., 2004); hence, I made the gaming sessions highly task-centred to gain insights about the software prototype. The evaluation process was informed by Lewis and Reiman’s (1994) guide to task-centred user interface design. For the final twelve test sessions, the procedure was as follows:

1. The first game was played with the AR system, and no other help was given to the new player.
2. The second game was played without the AR system, and no other help was given to the new player.

The testing conditions included two modifications of game rules: first, the games were only played till seven points and not 10 points because that was enough to gather sufficient data relevant for this research; and second, because the games were played to seven points, the maximum number of roads a player could build was reduced to 10 from 15 and the maximum number of settlements was reduced from five to four. This ensured consistent game play with a regular game session as the possible developments were in proportion to the maximum limit of seven points to win. Twelve tests were conducted with 12 new players, and three tests with experienced players. As shown in Figure 47, this is regarded as a near-optimal number of tests required to find all usability-related problems
from testing with users (Nielsen, 2012). Beyond this, there would be little gain in the data to justify the extra time and resources spent on testing.

Figure 47: Finding Usability Problems and Number of Tests Required

Image: Nielsen Norman Group

7.1.3 Choosing Users for Tests
The criteria for choosing the users to test were simple. First, the users must be people unfamiliar with Settlers of Catan, and second, the user should preferably be someone who does not regularly play board games.

It was important to find users who had never played Settlers of Catan before. The system was designed for new players at their first game; it would only partly serve the purpose of equalising the game between new and old players. So, I looked for users among peers, friends and family who, in addition to never having played Settlers of Catan, were new to board gaming in general.

7.1.4 Selecting the Tasks for Testing
The users were asked to follow the game rules. The AR system was designed to be used in playing the game; the focus was not on the use of the system itself, but on the actions that players took after they used the system. Therefore, the first two tasks for the new players were to pick up the initial two free settlements and thereafter follow a suitable early expansion strategy. Game length was also recorded to determine if new players are able to play near recommended game speed for Settlers of Catan, in this case for about 40 minutes. The five tasks were as follows:

1. Choose the node for the first settlement which had a high node value.
2. Choose a corresponding node for the second settlement based on resource variety strategy.
3. Choose the expansion steps considering high node values.
4. Formulate and follow a basic strategy.
5. Play with reasonable speed.

7.1.5 During the Testing Phase

*The Thinking Aloud Method.* When the users were asked to perform their tasks using the AR system, they were also asked to think aloud, describing what they were trying to do, the issues and questions that arose and how they related the information from the AR system to actionable information on the board game. I took notes of these observations.

*The Wizard of Oz Approach.* This is a method widely used in software testing, where in some cases some parts of the software are simulated (Dhalbak, 1993). This avoids having to develop comprehensive software before it can be tested by users. In this research project, the scope of the AR strategic hints module was to help the new player place the first two settlements. But the new player was given hints about the early expansion stage – building the next two settlements as well. Now, as the first two settlements the user places are not known to the system, the Wizard of Oz approach was used beyond that point. Moreover, Settlers of Catan has a variable game board, which means it can be constructed in a practically infinite number of ways (Katya, 2006). To write a comprehensive AR system that considers this fact was beyond the scope of this research. By using the Wizard of Oz approach, it was possible to test the AR system. The data collected during the testing phase was in form of notes and photographs.

7.2 Test Documentation

This section presents the documentation for one test session. The rest of the documentation for the other fourteen sessions can be found in Appendix IV.

*Test Session: Two games with D1*

Test subject D1 (indicated by the red arrow in Figure 48) does not play board games regularly, and has never played Catan. He is playing against experienced players. He is an ideal subject for testing the application. Before the game begins, I provide D1 with a very brief introduction to the game metaphor: the map representing an island full of different resources, and each player representing a settler’s community. I introduce him to the game components: the tokens for building and cards for
spending. This introduction to the game is very brief. Next, I instruct him on how to use the AR system. This includes only the basics of interaction: how to trigger the different AR overlays on the map and how to interact.

Then, D1 navigates through the AR tutorial for 10 minutes. Initially he is not sure about the interaction and triggers false commands, so I intervene to explain the fact that AR buttons work on occlusion and can be triggered by accidental movements. After this, D1 is more confident and his interaction with the AR overlays is smooth.

Game Session 1

After 10 minutes of interaction, we begin the game. D1 is playing against experienced, player C (marked by the blue arrow in Figure 49, and myself. D1 could ask for clarification and he could also refer to the Catan-QuickStartAR. As it is his first game, he takes a bit longer to decide on his first move. D1 chooses the first settlement reasonably well: 5-8-10 stone-brick-sheep, with a node value of 12. (Later when I asked him about his choice, he said, “That was easy, the app told me to pick this spot.” He was referring to the node values numbers from overlay 2.) He thus demonstrates remembering the node values from the overlay, although at this point it cannot be determined whether he has understood the concept.
For his next action, he knows the strategy to go for: look for the overlap of the two resources he
does not currently own. There is only one option for that combination on the map, and D1 sees it.
We are rolling the dice and earning resources.

For his next move, D1 is trying to build a settlement, but has to be told about the 2-node rule. This
information is not in Catan-QuickStartAR. He understands the 2-node rule after he has been told,
and proceeds to place the road correctly towards 3-4-6 wood-brick-stone. The other option would
be 3-8 wood-brick but D1 knows it is not as good as 3-4-6.
Next, assisted through the Wizard of Oz approach described in section 7.1.5, D1 upgrades his settlement, also knowing which one to upgrade first (the first one – 5-8-10). D1 reaches seven points first with the longest road and another settlement and upgrade, and we end the game (Figure 51).
Game Session 2

Next, we played a second game, without help from “Catan-QuickStartAR” for D1. Player C and I are playing our normal games this time. Figure 52 shows the initial settlements placed by D1.

![Figure 52: Initial Settlements Placed in Game 2](image)

In the initial settlements placement, D1 (Yellow) demonstrates retention of knowledge from the previous game or from Catan-QuickStartAR. From here, D1 moves on to make a settlement at 6-5-2 sheep-wood-wheat, and 9-10-11 sheep-brick-stone. As Player C and I are both playing our normal game, we expand aggressively to 3:1 port and wheat port for me (blue) and 4-5-11 wheat-wood-stone and 6-2 stone-wheat for Player C (green).

The three of us are on similar points totals; I am on 4, Player C and DK on 5, but displaying timely tactics, D1 takes the road and wins the game with seven points.
7.3 Findings

The functions of Catan-QuickStartAR were observed during the testing of the AR system with users. Twelve sessions were conducted with new players and three with experienced players to gather insights on the use of Catan-QuickStartAR to answer the research questions. In this section I present a summary of the analysis of the data gathered during the test sessions that leads to the discussion in the next section, as shown in Table 9. I discuss the 12 sessions of games played with 12 new players who learnt Settlers of Catan using Catan-QuickStartAR, inferring their game understanding and information retention from the AR system through their decision-making and subsequent actions taken during the course of the game.

10 participants were able to choose the first settlement correctly. This shows clear understanding of overlay 2 - node values. The node values are different on the new map on which the games were played, and the participants are able to understand the concept and make the correct decision in choosing the node for their first settlements. The two players who did not make the correct choice – Dh and L – were found to be playing using their own strategies (this is further discussed in Appendix IV).

Placing the second settlement is a more challenging task. This is because of the game dynamic: the order of placing settlements is decided by rolling the dice, players cannot have a predetermined position based on first settlement placement as they may not have the node available during their turn. Catan-QuickStartAR advises players to go for the resource variety strategy. This is a safe strategy to start with, and easy to follow for new players, but in the case of their desired spot being taken by another player, the players need to improvise and combine the concepts of resource variety with node values. This is a difficult correlation for new players in their first game, and thus I observed only seven players making the correct choice. The five players who plumped for the resource variety strategy as recommended by Catan-QuickStartAR were still following the hints, but not improvising their game by thinking about node values.

Eight players were successful in formulating a basic strategy. All the players who had corresponding nodes with resource variety and node values with high probabilities were obviously successful in having a basic strategy in place, but two players improvised after choosing the second settlement incorrectly, but expanding into the correct spot during the course of the game.

Most players (10) were able to choose the expansion steps correctly. Understanding node values is a must for this task, as well as following a basic strategy that they have in mind. It is difficult to explain why two players failed to choose their expansion steps correctly. They showed understanding of the
concept of node values, and had basic strategies, but perhaps they had another strategy in mind and were not able to choose between the two, leading to the disorganisation of their game because they had too many goals.

Finally it was observed that all new players played with reasonable speed. A regular game of Catan (10 points) with at least one new player lasts between 60 and 90 minutes. The games in the testing sessions were played to seven points, making a range of 30–40 minutes acceptable, but three games lasted only 25–30 minutes.

<table>
<thead>
<tr>
<th>Tasks the users had to perform</th>
<th>Results – Game 2 – Without AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Building the first settlement</td>
<td>10/12</td>
</tr>
<tr>
<td>2 Building the second settlement</td>
<td>7/12</td>
</tr>
<tr>
<td>3 Form a basic strategy</td>
<td>8/12</td>
</tr>
<tr>
<td>4 Choose the expansion steps correctly</td>
<td>10/12</td>
</tr>
<tr>
<td>5 Play with reasonable speed</td>
<td>12/12</td>
</tr>
</tbody>
</table>

Table 6: User Tasks and Results

The analysis was conducted using data derived from the 12 game sessions of the fifth iteration. Results observed for the functions of the AR intervention are shown in Table 7.

<table>
<thead>
<tr>
<th>Functions of the AR intervention</th>
<th>Results Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Be simple to learn and use</td>
<td>Fairly simple to learn, not simple to use</td>
</tr>
<tr>
<td>2 Provide contextual information</td>
<td>Provided contextual information</td>
</tr>
<tr>
<td>3 Information should be well structured</td>
<td>Information was well structured</td>
</tr>
<tr>
<td>4 Provide all basic information</td>
<td>Provides a reasonable amount of information</td>
</tr>
</tbody>
</table>
### Table 7: AR System Functions and Results Observed

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Help in making a good strategy</td>
<td>Does help in making a good strategy</td>
</tr>
<tr>
<td>6</td>
<td>Take the load off experienced players</td>
<td>Takes a reasonable amount of load off experienced players</td>
</tr>
<tr>
<td>7</td>
<td>Be non-intrusive to other players</td>
<td>Fairly non-intrusive</td>
</tr>
</tbody>
</table>

#### 7.4 Analysis and Discussion

Participants were visibly excited seeing the AR technology and how it worked, and understanding how to interact with the system required little explanation, but the actual interactions were not smooth. This is because of the technical limitations of using occlusion-based triggers which can register false intents if a player is careless. This was a challenge for all new players. The information provided was quite sufficient for all players, and they were able to play their first game without any help with confidence.

To help improve the data analysis, I explicitly distinguish between usability and usefulness. While it is certainly necessary to iron out the usability issues throughout the design iterations of the prototype as documented in the previous chapter, my focus is on usefulness, that is, the impact on improving the quality of the user experience of gameplay (not the usability of using the AR system) for game players in this case. Thus, I begin my assessment of the usability of ‘Catan-QuickStartAR’ by discussing the user tasks with which I measured performance, then I discuss the usefulness of ‘Catan-QuickStartAR’, that is, its ability to improve the quality of the user experience of gameplay.

The performance of the users was measured using five tasks, as follows:

1. Choosing a spot on the map with a high node value. Building the first settlement was a task that two users performed with an error in the first game. This can be attributed to the difficulty in recalling the information from the Nodes overlay, where the options for good locations on the game board are given. The rest of the ten users were able to perform this task correctly.

2. Building the second settlement was a task that the test subjects performed incorrectly in 5 of the 12 games. With AR, the hints for the second settlement are easy to understand. The highlights appear at overlaps of the resources that the new player is missing from their first settlement. This is easy to remember, but the user actions do not indicate this. The conflict
between resource variety strategy and the concept of node values is a challenging task for new players, and here the system had shortcomings in providing the correct advice. Part of the problem can also be attributed to the fact that initial placements in the game are decided by the random element of chance.

3. Can the user form a basic strategy? The hints given by the AR overlays for the placement of the first two settlements were through the resource variety strategy – the strategy in which players try to cover all five resources between their settlements. It was observed that four test subjects did not understand this strategy in their first game. This task was not directly supported by ‘Catan-QuickStartAR’, but had to be executed by the user understanding other parts of information and piecing them together.

4. Can the users choose the expansion steps correctly? The expansion steps in the game with AR were displayed using the Wizard of Oz approach (Section 3.5.4), and both test subjects were able to act accordingly. However, the rationale behind this was not understood by one player, as was observed in the second game. This task also was not directly supported by ‘Catan-QuickStartAR’, but had to be executed by the user understanding other parts of information and piecing them together.

5. Can the game be played with reasonable speed? The test sessions went on for between 30-40 minutes, which is an optimal speed for the shortened game, as the average full game lasts 60–90 minutes. All the test subjects were able to play both the games with reasonable speed, not taking excess time.

Now I present the analysis of the usefulness of ‘Catan-QuickStartAR’ in terms of the seven features of the AR system, following on from the outline presented at the end of Chapter 5.

- The AR system had to be simple to learn and use; it was observed to be fairly simple to learn, but not simple to use. The system overlays data on the board game map itself, in order to use the elements of the map as ‘virtual buttons’. The buttons worked on the occlusion principle – meaning a button is considered in its on state when it is occluded. This resulted in false triggers sometimes, as the users were occasionally careless with their hand movements in interacting with the data.

- The system had to provide contextual information. This was done through AR overlays, which by definition are registered to the physical tokens like cards and the map. This means
that whenever a particular overlay is displayed, the information on the overlay appears exactly as it would as designed in the software prototype.

- The information presented to the user had to be well structured. This was achieved by categorising the information on five AR overlays, and a main menu was designed that allowed the user to switch between the overlays. The information presented was structured in the order as found in the game manual, starting from the basic to the more complex.

- Provide all the basic information. This was done through structuring the information on different overlays. Five overlays were used in the tutorial, and going beyond that would have complicated the system. Hence the decision was made to leave the more complex information specifically related to the development cards out of the tutorial.

- Help in making a good strategy. The AR system provides information regarding the placement of the first and second settlements on the map. The assistance is provided in terms of augmented highlights displayed on the specific regions of the map. In addition to the initial placements phase, strategic help was given for the early expansion stage.

- Take the load off the experienced players. The system reduced the burden on the experienced players in terms of explaining the game rules exhaustively. In the test sessions, the new player did ask questions about specific things now and then, but these queries were minor.

- Be non-intrusive to other players. The system was fairly non-intrusive to the gameplay in general as it was designed to be used in the beginning of the game. The user acted upon the system’s instructions (displayed on the screen) in the early expansion phase. These instructions were simple enough to be grasped at a glance.

7.5 Conclusions

The following sections summarise the research outcomes and contributions of this research project in relation to the research questions.
7.5.1 Research Summary

This research has addressed problems that arise when people with different experience levels try to play a board game. When playing a board game, new players need to grasp a large amount of information to be able to play with speed and have a strategy to challenge experienced players. The information available to new players to learn the game rules and strategies is currently in the form of tools such as a printed manual, or through mobile or tablet applications. These tools available have significant limitations in use. The source of information is in a separate space, outside the board game, and the effort is required in searching specific information. These limitations affect the quality of game experience for new as well as experienced players, as the game activity is disturbed by the time it takes to refer to these separate sources of information.

I began this research by collecting real-world gameplay data over a period of several months using participant observation technique, inspired by ethnographic methods. I documented over 300 participant observations over several board game sessions. This helped generate a rich description of the problems arising in the scenario. It was observed that of the tools available for new players to learn a board game, the manual was rarely used, while the mobile or tablet applications were not used at all. New players preferred to learn a board game from experienced players. The problem here was that experienced players had to create an ad-hoc tutorial which sometimes lacked a structure, and some concepts had to be explained multiple times to new players. Moreover, in terms of game strategy, the more advice an experienced player provided, the more predictable the game became, while reducing the experienced players' chances of winning. Such game sessions were played as a ‘learning sessions’.

The motivation of this research was to use an AR approach to address the issues new players face in learning the basic rules of a game, and to assist gameplay in a manner that the game experience is fulfilling for all the players involved, in the very first game.

These challenges were formally undertaken through the following three research questions:

1. How can AR support new players to learn the game in-situ when player experience levels are different?

2. How can information be presented to support the understanding of basic game concepts and strategies?
3. How can the AR intervention be designed to make it interactive but non-intrusive to the gameplay?

The key observations from the data collection process using the participant observation technique were analysed using Engeström’s second generation Activity Theory framework. The result of this was a design outline for the development of the AR prototype. Research Through Design was used as a tool for generating and advancing knowledge. The knowledge was generated through the practical act of designing a software prototype ‘Catan-QuickStartAR,’ that underwent five design iterations. ‘Catan-QuickStartAR’ is validated through testing with users.

The three research questions embody the seven design guidelines for ‘Catan-QuickStartAR,’ presented in section 5.4. In the following discussion, I summarise the findings in terms of the design and technical features of ‘Catan-QuickStartAR’.

The first research question asked about the shape and form of the in-situ AR intervention in the scenario selected. The following two design guidelines embody this research question.

1. The AR system should be simple to learn and use: Learning the system had to be fast and intuitive. This was done by making the ‘virtual buttons’ on the physical game board stand out using a visual style different from that of the game board. The system has to be used with care, as AR technology has technical issues that can register false triggers. In addition, the fixed-camera Spatial-AR setup used for ‘Catan-QuickStartAR’ beyond the second iteration of the prototype ensured that the tracking errors were minimised and the technical limitations of AR applications do not complicate the use of ‘Catan-QuickStartAR’.

2. The AR system should provide contextual information: The information should relate to the real world. This was done by designing the augmented information registered to the physical object or region of space, using the ‘image target’ prefab in the software development environment using Vuforia SDK in Unity. The augmented information was triggered by having the physical object or region in view of the input camera.

The second research question asked about the presentation of information to support understanding of basic game concepts and strategies. The following three design guidelines embody this research question.
3. The AR system should provide all the basic information. This was done by identifying the information that should be presented to the user, and responding using images and short descriptions instead of long texts. For the board game Settlers of Catan, this involved all the information about the names of resources, and map elements such as production centres and ports. Following the previous design outline, the information was provided contextually, i.e. on the physical regions of the map to assist new users understanding different spatial and topological imageries and features.

4. The AR system should provide well-structured information. This was the most important design outline. Complex information needed a structure that assists understanding of the game concepts in smooth manner. The third iteration of the ‘Catan-QuickStartAR’ resulted in an information overload for users, and the main technical addition of an ‘AR-menu,’ achieved through the use of ‘virtual buttons,’ in conjunction with the design innovation of using five different overlays in a ‘tutorial’ format. Complex information was structured ‘horizontally’ on these layers that teach the users game concepts in a progressive manner: first the users were informed about the names of resources and what the game cards look like, then how the settlements are built and how to earn resources. Next, on ports and trading, and finally how to form a basic strategy. This progression was derived from the game manual, as well as the participant observations of real-world board game sessions. The users could switch between these overlays at their convenience, this was done using the technical feature of ‘scenes’ in Unity.

5. The AR system should help new players make a good strategy. The AR system provides information regarding the placement of the first and second settlements on the map. The assistance is provided in terms of augmented highlights displayed on the specific regions on the map. This was done using ‘virtual buttons’ on each of the nodes on the map. During the tests with users, in addition to the initial placements phase, strategic help was given for the early expansion stage.

The third research question asked how the AR system should be interactive and non-intrusive. The final two design guidelines embody this research question.
6. The AR system should reduce the reliance on the experienced players so that they can concentrate on their own part in the game. This has been achieved by making the system interactive. As new players could interact with ‘Catan-QuickStartAR’ readily, their understanding of the game rules came from the system, and not from experienced players. Thus the experienced players were able to concentrate on their own game.

The system was made interactive by using the feature of ‘virtual buttons’. This provided two benefits. First, it enabled the system to have more information on different layers by allowing the user to switch between the layers. Second, it made the board itself interactive, and relevant regions of the board were used as buttons to display information about them. The pre-calibrated sensitivity of the ‘virtual buttons’ helped to ensure ‘Catan-QuickStartAR’ was able to determine user intent and display relevant augmented information. This made the system highly interactive for new players, and thus reduced the reliance on experienced players.

7. The AR system should be non-intrusive to other players: The system was made reasonably non-intrusive by using a Spatial-AR setup that would reduce technical errors inherent to AR systems by splitting the camera input from the display output. The system was fairly non-intrusive to the gameplay in general as it was designed to be used in the beginning of the game.

This work highlights that AR is shifting from being a technology to being a viable medium for information that can support task-based user performance. In the next section I present the contributions made by this research.

7.5.2 Contributions
In addition to answering the research questions, the contributions of this research include the following:

AR can replace the game manual

My work demonstrates how AR can be used as a tool in a board game session, by players who prefer not to read the manual. It was observed during studying the game sessions that new players prefer to learn the game as they go. The primary problems with using a game
manual are that the information is a way from the place of action, and the act of searching that has to be performed to find the correct information in the manual. This is not only time consuming, but also cognitively challenging as there are perceptual discontinuities between the game manual and the game board.

AR is emerging as a viable medium for displaying information and creating in-situ training experiences. It enables presentation of information registered to physical objects, thus eliminating the process of searching.

Thinking about AR as a medium opens up new areas to explore

- AR Menu Design: Augmented menus have buttons for switching between different layers of information. This new opportunity has exciting applications, as the amount of information is no longer bound by the size of the physical objects. Most AR applications display a single overlay, but now it is possible to have multiple overlays and design navigation experiences through the information on the same physical object.

- Visual Communications: Elements and principles of visual communications, especially graphic design, come into play while formatting complex augmented information. When designing more complex information on the same amount of physical space, it is important to follow basic principles like association, balance and symmetry to ensure the information is grasped by the user without undue effort. More complex elements of visual communications may arise if AR, as a medium, is developed in this direction.

- View Management: The camera that takes input for an AR system can be detached from the display that gives the augmented view to the user. This will provide a major improvement in tracking the physical object. No longer constrained by the difficult image processing required to process images from a handheld device, AR can be deployed in a wider range of applications with a fixed camera for robust tracking. It may not be possible to build a dedicated AR setup for all scenarios, but many industrial scenarios are suitable for such fixed setups. Deploying AR on wearable devices like Google Glass could make the technical concerns of handheld-AR irrelevant.

- Occlusion-based triggers: A portion of the real world that is tracked by the AR system can have certain regions that trigger augmentations when they are occluded. This feature is the key to the Catan-QuickStartAR that I developed in this research. Occlusion-based triggers provide a novel mechanism to gauge user intent, through the simple act of occluding a part of a physical object that is tracked by an AR system. This potential for interaction is
immense: anything part of the physical world can be made to work as a hyperlink to a world of information.

7.6 Limitations of this Research and Future Enhancements

The major limitation of the research is the scope of the usability of the AR system. In the chosen game scenario, a fully-fledged support system was beyond my programming abilities; it would have to include a complete game logic system, which is an enormous task. I thus suited the scope of the AR system to my abilities and designed the testing procedure with specific goals.

Another limitation is that I present only one case of Settlers of Catan. The findings were specific to the game dynamics of this particular game such the moves and strategies possible. This remained a limitation due to the time constraints I faced in developing the AR software prototype. The design process underwent through five iterations to reach a level of usefulness for evaluation with users. If time had permitted, making another software prototype for another game would have generated a wealth of data through comparative analysis between the design process and evaluation with users.

For future enhancements, this research could be extended in two ways. Firstly, a similar application could be made for other board games. Board games with a map component are more suitable for this kind of AR setup that involves a fixed camera. Moreover, if wearable computing devices become more mainstream, specifically devices such as Google Glass, the scope of the AR system can be enhanced: future iterations of this research would most likely have to move to this new platform.

Finally, a general next step for this research would be in scenarios involving training users in operating a control panel for complex machinery or systems. Training in such scenarios is often expensive and difficult, but with an AR setup, new users can be trained by presenting annotated augmented information on the buttons of the control panel itself. For such scenarios, a fixed-setup implementation of an AR system may be more suitable.

7.7 Final Conclusions

In summary, this exegesis depicted a real-world problem scenario involving board games to which Augmented Reality adds value. Using ethnographic methods, real-world gameplay was investigated to generate a rich description of the issues. This data was analysed through the Activity Theory framework. The research then employed design as a tool for generating new knowledge. An iterative
design approach was used to create five software prototypes, which were subsequently evaluated to validate their use in a real-world scenario.

This exegesis also presented a snapshot of Augmented Reality technology in its current state, along with its development history. It adds weight to efforts to make Augmented Reality a more widely-used medium for accessing information. Ease of use and dependability are key challenges for Augmented Reality.

The process of designing made manifest a tangible software prototype. My focus as a designer was on that outcome as a work of design, and learning through the experience of designing, by engaging in the practical act of making the software prototype. The life of the evidential material produced in this research is fleeting due to the inevitable and rapid advance of technology, but it provides a sound foundation for the next proposition made by myself, or by others, in the future.

This research demonstrated how a support system for new players of a board game can be made using Augmented Reality technology. I hope such systems shall one day eliminate manuals in board games and from other scenarios as well.
References


Cameron, J. (Director). (2009). *Avatar*. [Motion Picture]. United States: Twentieth Century Fox Film Corporation


Appendix I

Ethics Approval, Participant Information and Consent Form
Notice of Approval

Date: 3 July 2013

Project number: CHEAN A-2000863-04-13

Project title: A Design-led Investigation of Augmented Reality

Risk classification: Low Risk

Investigator: Naman Thakar and Dr Flora Salim

Approved: From: 3 July 2013 To: 3 July 2016

I am pleased to advise that your application has been granted ethics approval by the Design and Social Context College Human Ethics Advisory Network as a sub-committee of the RMIT Human Research Ethics Committee (HREC).

Terms of approval:

1. Responsibilities of Investigator
   It is the responsibility of the above investigator/s to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by the CHEAN. Approval is only valid whilst the investigator/s holds a position at RMIT University.

2. Amendments
   Approval must be sought from the CHEAN to amend any aspect of a project including approved documents. To apply for an amendment please use the 'Request for Amendment Form' that is available on the RMIT website. Amendments must not be implemented without first gaining approval from CHEAN.

3. Adverse events
   You should notify HREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Participant Information and Consent Form (PICF)
   The PICF and any other material used to recruit and inform participants of the project must include the RMIT university logo. The PICF must contain a complaints clause including the project number.

5. Annual reports
   Continued approval of this project is dependent on the submission of an annual report. This form can be located online on the human research ethics web page on the RMIT website.

6. Final report
   A final report must be provided at the conclusion of the project. CHEAN must be notified if the project is discontinued before the expected date of completion.

7. Monitoring
   Projects may be subject to an audit or any other form of monitoring by HREC at any time.

8. Retention and storage of data
   The investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

In any future correspondence please quote the project number and project title.

On behalf of the DSC College Human Ethics Advisory Network I wish you well in your research.

Daniel Martini
Ethics Coordinator (Acting)
College of Design & Social Context
RMIT University
Ph: (03) 9925 3283
daniel.martini@rmit.edu.au
INVITATION TO PARTICIPATE IN A RESEARCH PROJECT

PARTICIPANT INFORMATION & Consent Form

Mental Models and Board Games: to gain insights into how people learn and act in systems of rules, into players’ mental models, and the role of technology in this process.

Chief Investigator: Naman Thakar, Spatial Information Architecture Laboratory (SIAL)/Architecture and Design/Design and Social Context, ph 0415509950 email s3316658@student.rmit.edu.au

Supervisor: Dr. Flora Salim, Spatial Information Architecture Laboratory (SIAL)/Architecture and Design/Design and Social Context, ph 99254572 email flora.salim@mit.edu.au

Dear ....................,

You are invited to participate in a research project being conducted by RMIT University. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

Who is involved in this research project? Why is it being conducted?

I shall be employing ethnographic methods to study the game play of a popular board game. Data shall be collected will be by the participant observation technique and video will be recorded for making a detailed report for each session. Participants shall be given a short pre-game and post-game questionnaire.

The overall research agenda is to gain insights into how people learn and act in systems of rules, into players’ mental models. The goal is to find out how technology can play a role in this process. I started research into augmented reality, and am keen to determine what sort of an intervention is most beneficial for a particular setting of activities. It could be in the form of a pen, paper, assistive mobile apps, user interaction and experience through a control pads etc. The form of output shall be determined by further knowledge generated through these sessions about the mental models required for learning.
Why have you been approached?

For your interest in gaming, which will help gather quality data that will help understand the mental models of players. Gaining insights into how players learn and play games through physical actions, some form of technological intervention shall be designed. This could be in the form of basic information storage/retrieval structures, to start.

If you agree to participate, what will you be required to do?

Be present at the venue for a briefing on the session. The introductory session will be followed by a short questionnaire, this will be followed by an introduction to the board game, playing the game itself, and a post-game questionnaire/discussion session. Total time estimated is 2 hours (maximum).

What are the possible risks and disadvantages?

There are no direct risks of physical or emotional harm, we are just going to play a board game. If you don’t mind losing, and slow players, it will be a good experience. There is a little public dimension to this project, as third party viewing and discussing of data is an integral part of research. This request to assign permission to reproduce work from these sessions extends this expected public dimension.

What are the benefits associated with participation?

You will be introduced to “the board game of our time”, or, if you are already familiar with the game, it will introduce a strategy framework for the game.

What will happen to the information you provide?

Your response to the release form will guide the next phase of this research.

What are my rights as a participant?

- The right to withdraw from participation at any time.
- The right to have any unprocessed data withdrawn and destroyed provided it can be reliably identified.
- The right to have creative works credited in the manner as wished.
- The right to have any questions answered at any time.

Whom should I contact if I have any questions?

Naman Thakar s3316658@student.rmit.edu.au

Dr Flora Salim flora.salim@rmit.edu.au (chief investigator)
Yours sincerely

Naman Thakar

Dr Flora Salim

-----------------------------------------------------------------------------------

PARTICIPANT’S CONSENT

1. I have had the project explained to me, and I have read the information sheet.
2. I agree to participate in the research project as described:
   Subject to the release form, I agree to the use of appropriately captioned and
   attributed material, both visual and written including models and written
   answers to questionnaires produced. I acknowledge that:
   (a) I understand that my participation is voluntary and that I am free to
       withdraw the use of my written and visual material in research and
       publication activities at any time and to withdraw any unprocessed data
       previously supplied (unless follow-up is needed for safety).
   (b) The use of my written and visual material is for the purpose of research.
       It may not be of direct benefit to me.
   (c) The privacy of the personal information I provide will be safeguarded
       and only disclosed where I have consented to the disclosure or as
       required by law. All use of my work will be credited as I have directed in
       the release form
   (d) The security of the research data will be protected during and after
       completion of the study. The data collected during the study may be
       published, and a report of the project outcomes will be provided to.

Participant’s Consent

Participant

Date:

(Signature)

Any complaints about your participation in this project may be directed to the Ethics Officer, RMIT Human Research Ethics Committee, Research & Innovation, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 2251.

Details of the complaints procedure are available on the [Complaints with respect to participation in research at RMIT](#) page

-----------------------------------------------------------------------------------

PERMISSION FORM

INTELLECTUAL PROPERTY
1. I, ________________________________, grant, Naman Thakar, and Flora Salim, a non-exclusive, irrevocable, royalty free, worldwide and perpetual licence to copy, reproduce in material form, publish, adapt, alter or modify, merge with other material, transmit or communicate to the public any data and images collected during any of my participation in this research project, along with any related written or electronic communications created by me for use for the following purposes:

   - Made available on an RMIT or externally approved web site for promotion or educational purposes
   - To be incorporated into RMIT promotion materials and activities for internal and external purposes
   - Incorporated into printed publications to be distributed both locally and internationally
   - Incorporated into SIAL’s Central Media Server, including archived onto CD/DVD as part of the Info Corner Library for promotion or educational purposes
   - Made available on various forms of electronic media such as CD-ROM, signage, or displays.
   - To be screened/exhibited publicly as part of RMIT or externally approved exhibitions / events

2. PRIVACY

I authorise and consent to the collection, storage, use and disclosure by Naman Thakar, (Project leader) and Flora Salim of images, photographs or written/electronic information about any course work projects created on the date/s indicated below for promotional and educational purposes, for example, in the following:

   - Made available on an RMIT or externally approved web site for promotion or educational purposes
   - To be incorporated into RMIT promotion materials and activities for internal and external purposes.
   - Incorporated into printed publications to be distributed both locally and internationally
   - Incorporated into SIAL’s Central Media Server including archived onto CD/DVD as part of the Info Corner Library promotion or educational purposes
   - Made available on various forms of electronic media such as CD-ROM, signage or displays
   - To be screened/exhibited publicly as part of RMIT or externally approved exhibitions / events

3. Participant ________________________ Date: ____________________

(Signature)

Name: ______________________________________

Email: ______________________________________
Basic Information Sheet

About the board game: The Settlers of Catan

The Settlers of Catan is a multiplayer board game designed by Klaus Teuber and first published in 1995 in Germany by Kosmos. Players assume the roles of settlers, each attempting to build and develop holdings while trading and acquiring resources. Players are rewarded points as their settlements grow; the first to reach a set number of points is the winner. The Settlers of Catan was one of the first German-style board games to achieve popularity outside of Europe, it has been translated into thirty languages from the original German. It has been called "the board game of our time" by the Washington Post.

My Research Agenda During Game Sessions

I shall be employing ethnographic methods to study the gameplay, specifically the decision points in the game. Data will be collected by the participant observation technique and photographs will be taken during the game sessions to generate a detailed report. You will participate in a short post-game questionnaire; further discussions about board gaming are very welcome!

My Overall Research Agenda

My research is investigating into Augmented Reality as a technology for potential game intervention. The aim is to target the early game phase where new players will be given information through an Augmented Reality system about the basic concepts of the game, and help with choosing a strategy for the game. The goal is to democratis information so that new players can present a challenge to experienced players without the use of the manual or asking experienced players for help.
Appendix II

Ethnographic Observations
Ethnographic Insights Summary:

Top 50 recurring observations

1. Better presentation of the game rules helps new players learn what is most important.
2. The speed of the tutorial needs to consider new player’s concerns about some topics.
3. The concepts presented together need a hierarchy or progression.
4. Better game presentation required.
5. New players just want to start playing the game.
6. New players become restless if the tutorial is too long.
7. Some rules need to be better explained.
8. Players feel comfortable with asking questions in their turn.
9. Game tutorial and the following game play should not overlap too much.
10. The teacher needs to be sensitive to player’s decisions, and needs a better narrative.
11. The first game should not be too hard for the new player.
12. Better tutorials can help new players understand the basic concepts
13. New players can learn new rules better with breaks in between.
14. Game genre has to be made explicit before the start of the game.
15. Fluid game mechanics are good, they keep the game interesting.
16. The Teacher should conduct his role with care.
17. Better tutorials should help in game tactics as well as strategy.
18. Some factors in a game naturally excite people to collaborate.
19. Advice from the game teacher should be timely and accurate.
20. New players should not be de-motivated by game events.
22. Unexpected things in the game make new players feel de-motivated.
23. Cooperative games are a very different game mechanic from competitive games.
24. New players reach a certain threshold beyond which they cannot grasp any more rules.
25. Enacting is the only way you can explain some rules.
26. If an expert player explains the rules too much, new player stops learning and playing effectively.
27. New players endure a game they don’t understand the rules of too much.
28. Expert player’s tutorial can be biased by their style, this style can be convoluted.
29. Expert player’s tutorials can miss certain important points in the narrative.
30. Tutorials have to be better structured through an engaging narrative.
31. New players do not have the freedom to understand the game as they like.
32. New players find it hard to differentiate between game critical and game play information.
33. Tutorials have to be better structured, explaining important points.
34. New players can get extremely frustrated with expert player’s tutorials.
35. Tutorials need to be better structured and have a clear hierarchy of information
36. New players can lack confidence to resolve their queries by asking other players
37. New players don’t need to win to enjoy their first game.
38. Tutorials have to be better structured.
39. Once the mood of the game was spoilt, it stays like that.
40. Nobody enjoys a game after an argument.
41. Some game rules can only be explained through enacting them.
42. New players can get confused if there is more than one source for learning.
43. New players prefer to start playing the game and learn as the game progresses than to know all the rules before starting.
44. New players can make the correct choice of actions with the right information.
45. If experienced players give complex advice, it does not help new players because they may not understand the reasoning behind it.
46. New players just want to start playing the game.
47. New players need guidance on game strategy
48. Experienced players can mislead new players on the wrong strategy.
49. New players can follow an incorrect strategy
50. New players can be de-motivated if their strategy does not work well
51. New players need a fairly good strategy in their first game.
52. New players want a sense of control over the game.

All Observations during 11 Games

Game 1 FLASH POINT

1. Six players, clockwise from me: Me, B, S, B 2, M, and N. B is explaining the game.
2. He is speaking too fast and the rules are many.
3. Player order - anti clockwise from me: Me, B, Randomguy, B 2, M, N.
4. Only B knows the game, rest all are new players.
5. B is very enthusiastic about explaining the rules.
6. The game has lots of tokens: fire, smoke, black cubes, dice, ambulances, player firefighter figures.
7. B is explaining everything in a random manner, it is difficult to associate the tokens with their actions.
8. B is playing a new version of the game, so is not sure about some new features.
9. There are several firefighter roles - each player picks up a role card and a corresponding figure to play with on the board.
10. M goes for blue colour, says it is her favourite.
11. Players spend time guessing which role corresponds to which figure.
12. “It doesn’t really matter,” B says, “Each figure gets a coloured base as well, so that helps.”
13. B has a favourite fireman he wants to play with.
14. Explains damage cubes, if all the damage cubes are on the walls, we immediately lose the game, the building falls down. This is how we lost the first game and new players didn’t really pick up on this fact. It did not come across as something important.

AS A NEW PLAYER IT IS DIFFICULT TO DIFFERENTIATE BETWEEN GAME CRITICAL INFORMATION AND THE GAME PLAY INFORMATION.

15. Explains fire-markers. The way fire appears: there is a smoke. Says if we have to add smoke to the board and there already is smoke, it turns into fire.

DOES NOT EXPLAIN HOW AND WHY AND WHERE FIRE STARTS.

16. Links between fire and smoke and walls explained. It is not clear to me, but B goes on to explain “doors” in the building.
THERE IS NO TIME TO INTERRUPT HIS EXPLANATION TO ASK ANY QUESTIONS.

17. Doors disappear when there are explosions in the building, doors are the first ones to go. But they absorb a bit of the explosion before they go.

ABRUPT INTRODUCTION TO THE CONCEPT OF EXPLOSIONS. DIFFICULT TO LINK THE CONCEPTS TOGETHER.

18. We were playing the harder version of the game, with only two doors in and out of the building. So there are multiple versions, I wonder why we are playing the harder version with so many new players.

19. Concept of chopping through the walls to get to another room, - but you add damage cubes to the building!

20. Mentions that this will hasten the building collapse, but it is necessary sometimes and thus has to be done.

21. There is Hazmat materials on the board as well, if that gets hit by the fire there is an explosion. But there are hazmat technicians. We can carry these materials off the board as well.

TOO MANY NEW CONCEPTS!! DIFFICULT TO FORM LINKS BETWEEN THEM.

22. Paramedics can heal people. There are some healing tokens that help move victims faster.

23. There are fifteen people tokens: 5 blank and 10 people and pets.

24. There is a discussion about one pet token: squirrel or a meerkat or something.

25. Interruption - new guy hovers around, Random guy was looking for a way out, they swap seats.

26. S is now playing - he is not familiar with the game as well.

27. B explains about rescuing people, taking them “there” after ambulance action, if they die, they go “there.”

28. As soon as we have 7 people there we have won, and as soon as we have 4 people there we have lost.

29. Thus there are two ways to lose the game: building collapses if all damage tokens are on the map, or 4 people die in the fire. Only one way to win: 7 people safe.

30. Did I mention? This is a cooperative game, so people have to play with each other as a team, and not compete with each other. This was my first cooperative game.

31. Playing on medium difficulty level because lower difficulty is way too easy.

32. B says that’s all for the rules and we are starting the game.

33. Then he rolls the dice multiple times and places fire and smoke tokens on the map.

THE GAME SETUP IS STILL GOING ON, AND IT FEELS UNFAIR TO NOT START THE GAME AFTER THAT LONG A RULES EXPLAINING SESSION.

34. B places explosions and fire. There are “hotspots” on the map where a fire starts. If there is no fire, only a smoke token appears.

35. Everyone is patiently listening. I am not sure if B is explaining the game still or has the game already begun.

36. The second explosion! Walls with one damage cube cannot be walked through. Only walls with two damage cubes can be walked through.

37. So that’s the start of the game!

FINALLY! WE GET TO PLAY!
38. “There are also these materials someone left behind, we do that by rolling the dice again.”

WHAT NOW?!

39. The materials behave exactly like people when you have to drag them out.
40. Explains about the engine spraying water on a quarter of the board, but you can only do it if there are no firefighters standing in that space. Takes the entire turn to play it unless you have the deck gun specialist.
41. Mentions that you can change roles now.

WASNT CLEAR TILL IT OCCURRED IN THE GAME THAT YOU CANNOT SPRAY WATER ON THE WHOLE QUARTER, YOU ONLY CHOOSE A QUARTER AND THEN ROLL THE DICE.

42. Mentions the starting position. Says you can enter through doors, but you can also smash a wall to make a new entrance, perfectly legitimate.

B WAS JOKING BUT IT WAS DIFFICULT TO PICK IT UP. SEEMED LIKE GOOD ADVICE.

43. B mentions his tactic ... other players did not understand.
44. Explaining action points now. About moving around on the fire engine, and changing roles and firing the deck gun.
45. Each turn has 4 action points + more if your special character has more.
46. S’s turn. B explains still more rules.
47. M recaps her firefighter abilities when it is her turn.
48. N reviews all actions available on her turn.

PLAYERS ARE CLARIFYING THEIR DOUBTS ONLY WHEN THEIR TURN COMES, THEY DO NOT INTERRUPT BEFORE IN THE TUTORIAL.

49. I do the same because I feel comfortable about asking questions at that point.

PLAYERS FEEL IT IS OK TO ASK QUESTIONS AND HALT THE GAME ON THEIR TURN AND NOT ON OTHER TURNS.

50. B explains a lot but says “I’ll let you do what you want.” The danger of cooperative games is that one guy becomes the alpha male and dictates actions to other players.
51. It is up to you, play the game, enjoy the game.
52. First role is an explosion.

STILL EXPLAINING THE RULES - NOW ABOUT FIRE PROGRESSION.

53. More explosion - hard game is a good game B says.
54. More fire, more explosions. This might be over quickly.
55. B explains something about the small arrows on the board.

IT IS DIFFICULT TO PAY ATTENTION TO NEW FACTS BEING EXPLAINED WHEN YOU ARE TRYING TO PLAY THE GAME. I WASNT PAYING ATTENTION AS I FELT LIKE I COULDN’T UNDERSTAND EVEN ONE SENTENCE MORE.
56. Game moves on, more explosions and walls damaged.
57. Players are still clarifying their doubts.

B TRIES TO GIVE “GOOD ADVICE” WHICH IS SOMETIMES CONTRARY TO THE DECISION THAT THE NEW PLAYER HAS COME AT.

58. M is trying to think for others, suggesting actions.
59. The game is looking more bleak, by many explosions and fire.
60. N uses the deck gun option, but was not clear on the use of it. She thought the deck gun can be used on the whole quadrant.

IF THE PLAYER EXPLAINING THE GAME MAKES AN ERROR, PLAYERS CAN BE UNINTERESTED IN THE GAME WHEN THEIR ASSUMPTIONS ARE WRONGED.

61. I am not sure about my actions options and try to involve people in my turn.
62. One more, last explosion and all damage tokens are on the map: the building has collapsed and we all have died. B: I was hoping to end this game quickly because our luck was very bad. M: Maybe we should think about who we are and rethink who we want to be. Discussion on the roles of different players.
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>As a new player it is difficult to differentiate between game critical information and the general gameplay information.</td>
<td>Better presentation of the game rules helps new players learn what is most important.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>There is not time to interrupt his explanation and ask any questions.</td>
<td>The speed of the tutorial needs to consider new player’s concerns about some topics.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Abrupt introduction to the concept of explosions. Difficult to link the concepts together.</td>
<td>The concepts presented together need a hierarchy or progression, and (1)</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Too many concepts! Difficult to form links between them.</td>
<td>Better game presentation required, and (3).</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>The game setup is still going on, and it feels unfair to not start the game after that long a rules explaining session.</td>
<td>New players just want to start playing the game.</td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>Finally! We get to play!</td>
<td>(5)</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>What now?!</td>
<td>New players become restless if the tutorial is too long.</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Wasn’t clear till it occurred in the game that you cannot spray water on the whole quarter, you only chose a quarter and roll the dice.</td>
<td>Some rules need to be better explained, (1)</td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>B was joking but it was difficult to pick it up. Seemed like good advice.</td>
<td>(3)</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Players are clarifying their doubts only when their turn comes, they do not interrupt before in the tutorial.</td>
<td>Players feel comfortable with asking questions in their turn.</td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Players feel it is OK to ask questions and halt the game on their turn and not on other turns.</td>
<td>(10)</td>
</tr>
<tr>
<td><strong>12</strong></td>
<td>Still explaining the rules – now about fire progression.</td>
<td>(7)</td>
</tr>
<tr>
<td><strong>13</strong></td>
<td>It is difficult to pay attention to new facts being explained when you are trying to play the game. I wasn’t paying attention as I felt like I couldn’t understand even one sentence more.</td>
<td>Game tutorial and the following game play should not overlap too much.</td>
</tr>
</tbody>
</table>
B tries to give ‘good advice’ which is sometimes contrary to the decision that the new player has come at. The teacher needs to be sensitive to player’s decisions, and needs a better narrative.

If the player explaining the game makes an error, players can be uninterested in the game when their assumptions are wronged. (14)

**Game 2 FLASH POINT**

1. B gets a new map out. After the poor performance in the last game session, we scale down the difficulty a bit, and now we are playing the “easy” map.
2. The “easy” map has lesser walls in the house, and more entrances and exits for speedy evacuation.
3. B comments that the hazmat tokens make the house seem like a meth lab.

**THERE SHOULD BE A FIRST-TIME GAME SCENARIO WHICH DOES NOT INCLUDE THESE AND SOME OTHER TOKENS.**

4. Putting the other tokens: hotspots and people, firefighters and fire engine.  
   **I MISSED OUT ON THE RATIONALE ON THE PLACEMENT OF THE FIREFIGHTERS OUTSIDE THE HOUSE.**

5. S wants to become the Rescue Dog. B explains the abilities: he can run very fast around the house, jump through damaged walls and sniff out people from false alarms. But he cannot carry hazmat materials, or people out.

**EVERYONE SEEMS INTERESTED TO LEARN SOMETHING NEW ABOUT THE GAME. THIS IS A BIT OF NEW INFORMATION AFTER A LITTLE WHILE.**

6. B focuses on the negative aspects for the Dog, discouraging S from taking it. S takes the Dog anyway, everyone is happy about it. It is a stupid character. You are going to make us loose, but I respect you for that. “This was introduced because the fans thought it was a fun character. But it is not a cool character and not very useful.”

7. B starts the game, and then goes away for a bit. The group is in intense discussion. Everyone is suggesting options for every move.

**IT IS A HEALTHY DISCUSSION, IN THE ABSENCE OF THE GAME ALPHA. B WAS CONSCIOUS OF NOT PLAYING THE ALPHA ON THE GAME, BUT IT HAPPENED IN A MANNER THAT EVERYONE THOUGHT HE WAS.**

8. M is the only one who is very hostile towards the dog, making moves that specifically do not help the dog.

9. Flipping the dice is a different function to mirroring the dice!

10. This is how the game normally looks like.

11. My turn actions are missing the link to other players’ abilities. I am worried about optimizing my actions, missing out on optimizing my actions for other players as well.
CANNOT THINK COOPERATIVELY YET. FOCUSING ON MY ACTIONS ONLY.

12. People are discussing the Dog actions. The dog has 12 movement points per turn, so can run around quite a bit: players share their thoughts on how dog should be running around.

13. There is an explosion and more fire, the board suddenly looks challenging and not very easy. B mentions this game can flip on the turn of the dice.

   THIS IS SAID LIKE IT IS A GOOD CHARACTERISTIC OF A BOARD GAME: THE GAME CAN FLIP ON A SINGLE TURN OF THE DICE. YOU CAN NEVER BE COMPLACENT IN THE GAME.

14. Long discussions on N’s actions. B advocates chopping the walls to make a door on a spot. Then says it is a bad idea.

   B IS TRYING TOO HARD TO GIVE UNBIASED ADVICE, TO THE POINT OF IT BEING CONFUSING AND UN-ACTIONABLE.

15. “Maybe I will use my action points to open the door and go inside... I don’t know...”

   GAME GOALS ARE CLEAR, BUT WHAT ACTIONS TO TAKE ARE NOT CLEAR.

16. M is vocal about the uselessness of the dog now. The question is about the dogs abilities to carry people. B seeks help “on the internet.”

   B RESORTS TO ONLINE FORUMS TO CLARIFY HIS DOUBT.

17. I am working as a generalist. No special actions, just running around putting out fire. I take one hazmat out. Everyone reckons it is a good move. This reassures me I’ve made a good move.

   ENCOURAGEMENT FROM OTHER PLAYERS MOTIVATES ME TO PLAY BETTER.

18. People are collaborating more with other players, thinking cooperatively. M is getting more involved with the overall coordination of the squad.

19. The ferret is rescued.

20. Can the dog run through smoke?

   DOG, THE NEW FACTOR IN THE GAME MECHANIC IS GETTING PEOPLE TO COLLABORATE MORE THROUGH DISCUSSIONS ABOUT ITS ACTIONS.

21. M tries the alpha role. She is the fire captain and can make two players move on her turn. B is helping her make decisions, but there is a hint of tension between them.

   THIS ESCALATES IN A LATER GAME.

22. I’m doing more of moving around, little jobs. This might not be a big change in the game (like hosing down a part of the house) but feels more immersive.

23. B is adamant on optimizing his fire-fighter actions, not rescuing a victim because it is not his speciality. Fair point, but he assumed too much that the other players are going to complement his abilities.
THIS DOES NOT HAPPEN, AND THE PERSON HE DOES NOT RESCUE DIES.

24. First deadly explosion! Everyone cheers for it, because the fire is spreading, and making the game more challenging.
25. Another explosion, more fire.

PLAYERS WERE GETTING EXCITED ABOUT THE GROWING CHALLENGE BUT NOW AFTER THE SECOND EXPLOSION THEY ARE NOT SURE.

26. Another victim dies.
27. B coordinates the ambulance movement and movement for other players, getting them around the house. But ends it with “that’s just my suggestion.” M counters him straightaway by proposing alternative move actions. B reasons his move actions, and his makes more sense. M ponders over another alternative move actions.
28. Other players are quietly doing their thing. M and B are discussing more and more about the overall strategy.
29. More fire spreading through the hotspots.
30. The dog uses 18 moves in one turn: 12 of the turn and 6 leftover moves fort the last turn. Everyone thinks that is amazing, there is a lot of cheer. N mentions that it is good to see everyone on board with the dog now.
31. Discussions on the mobility of the ambulance. B gives hints on which firefighters should move and which should stay behind.
32. M moves in a way that N has to use the deck gun in her turn.
33. Another explosion. One pet died.
34. N uses the deck gun twice with pointers from M.

THERE IS DEPENDENCE DEVELOPING BETWEEN N AND M.

35. There is more fire, and explosions by N.
36. I move things around, put out fire. On my roll there is more fire on the board.
37. Everyone notices there is only one damage cube left on the board, the building will come down soon.

SUDDENLY PEOPLE REALIZE WE MIGHT LOSE THE GAME BECAUSE OF OVERLOOKING THE DAMAGE CUBE COUNT.

38. B mentions that it is very worrying because we only have one cube left, B 2 mentions that if there is another explosion we all die. B sadly agrees.
39. We needed structural engineers. But there was no time.
40. The dog dies in the fire. “Such heartbreak!”
41. We have saved 3 people and M asks if we save one more person we win?

WHEN DEFEAT IS NEAR, EVEN NEW PLAYERS TRY TO MAXIMIZE THEIR GAINS FROM THE GAME.

42. One more person dies in the fire.
43. One more explosion, last damage cube on the map, building collapses, game over. We lose.

B mentions this is the only game he knows and he is happy to play more. But I say I’d like another game, a different game. N agrees. M does not mention her decision. B 2 is also there, saying nothing.
A bit more of game discussion, B has several kickstarter game boards with different buildings.

<table>
<thead>
<tr>
<th>No</th>
<th>Key Observation</th>
<th>Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There should be a first-time game scenario which does not include these and some other tokens.</td>
<td>The first game should not be too hard for the new player.</td>
</tr>
<tr>
<td>2</td>
<td>I missed out on the rationale on the placement of the fire fighters outside the house.</td>
<td>Better tutorials can help new players understand the basic concepts</td>
</tr>
<tr>
<td>3</td>
<td>Everyone seems interested to learn something new about the game, this is a bit of new information after a little while.</td>
<td>New players can learn new rules better with breaks in between.</td>
</tr>
<tr>
<td>4</td>
<td>It is a healthy discussion in the absence of the game alpha. B was conscious of not playing the alpha on the game, but it happened in a manner that everyone thought he was.</td>
<td>A Game Alpha does not help the game flow, especially for new players.</td>
</tr>
<tr>
<td>5</td>
<td>Cannot think cooperatively yet. Focussing on my actions only.</td>
<td>Game genre has to be made explicit before the start of the game.</td>
</tr>
<tr>
<td>6</td>
<td>This is said like it is a good characteristic: the game can flip on a single turn of the dice. You can never be complacent in the game.</td>
<td>Fluid game mechanics are good, they keep the game interesting.</td>
</tr>
<tr>
<td>7</td>
<td>B is trying too hard to give unbiased advice, to the point of it being confusing and un-actionable.</td>
<td>The Teacher should conduct his role with care.</td>
</tr>
<tr>
<td>8</td>
<td>Game goals are clear, but what actions to take is not clear.</td>
<td>Better tutorials should help in game tactics as well as strategy.</td>
</tr>
<tr>
<td>9</td>
<td>Dog, the new factor in the game mechanic is getting people to collaborate more through discussions about its actions.</td>
<td>Some factors in a game naturally excite people to collaborate.</td>
</tr>
<tr>
<td>10</td>
<td>This does not happen, and the person he does not rescue dies.</td>
<td>Advice from the game teacher should be timely and accurate.</td>
</tr>
<tr>
<td>11</td>
<td>Players were getting excited about the growing challenge but now after the second explosion they are not sure.</td>
<td>New players should not be de-motivated by game events.</td>
</tr>
<tr>
<td>12</td>
<td>There is dependence between N and M.</td>
<td>Better tutorials can help reduce player</td>
</tr>
</tbody>
</table>
13 Suddenly people realize we might lost the game because of overlooking the damage cube count.

Unexpected things in the game make new players feel de-motivated.

14 When defeat is near, even new players try to maximize their gains from the game.

Cooperative games are a very different game mechanic from competitive games, and (5)

**Game 3 SEVEN WONDERS**

1. M explains the game. Game tokens are distributed.
2. Game tokens include: money points. Army points. Civilization cards, and three sets of game cards.
3. Game cards of the first set are played in the first round. Each player gets seven cards, picks up one card and passes the rest to the next player. This goes on till everyone the deck is empty.
4. At this point, the army points are sorted and game moves on to level 2: picking cards from the second set. These are cards which have abilities to use cards from first set.
5. And after sorting the army points, the game moves on to cards set 3.
6. Cards in the first set are mostly resource cards, mostly free because you don’t have enough money. Some cards allow you to use other player’s resources. Some cards have victory points.
7. Cards in the second set are buildings cards and some resources.
8. Cards in the third set are high-level buildings that require several resource cards to be bought.
9. In later rounds things get more expensive. In the earlier rounds they are cheaper to buy.
10. Some examples discussed about the buildings that you have which help building more buildings in the next rounds.
11. Military cards give military points. At the end of each round, there are three rounds, there is military check. The more you have at the end of the round, you get that many military points.
12. The wheel, the abacus, the wreath. There are 7 points for every set.

**BY THIS TIME, I'M NOT TAKING ANY NEW RULES IN.**

13. For every blue/brown/green card you will get that many points.
14. Pick up a strategy and then play accordingly.
15. M is explaining how the cards move around, and says “It is really hard to explain without doing it.” And then enacts the gameplay with sample cards.

**IT IS VERY DIFFICULT TO EXPLAIN SOME GAME ELEMENTS WITHOUT ENACTING THEM.**

16. How to burn cards and earn points also explained.
17. These are the rules, you'll learn as we play along...
18. B adds on some tactics. Stresses on production cards, in round 1 and 2.
19. N and I ask B questions. B explains and does not share his opinion in his manner.
20. I ask questions about earning and paying. My civilisation has stones, others’ have other resources.
21. Game moves on, without much player interaction. Round 1 is over, military points are counted.
22. Round 2 starts. N is depending more and more on M for clarifications on her doubts.

   **M IS PLAYING FOR N’S STRATEGY.**

23. Round 2 over, military points counted.
24. Round 3 begins. Now the cards are more challenging to figure out what they mean.
25. I ask B sometimes for clarifications, but mostly I’m just picking cards with little reason.

   **I AM PLAYING ONLY TO PLAY. I’M NOT GETTING MUCH OUT OF THIS GAME. ITS TOO COMPLEX AND COMING THIS FAR, I DON’T WANT TO ASK FOR ANY MORE CLARIFICATIONS.**

26. I decide to go for little military points because I’m getting basked up on both sides.
27. Set 3 is over. Game play is over, M counts all the points.
28. Each of us count the number of points we have for 1. science, 2. money, military, 4. development.
29. Point count is added up and revealed: N and I are on 34 points each. B 2 is on 36 points. M is on 44. B is on 57 and S on 76.
30. The scores nicely illustrate player’s expertise and familiarity with the game. N and I were both new players, finished joint last. B 2 had played once before, so was next last. M knew quite a bit, and B and S were pros at the game, so they scored the most points.

<table>
<thead>
<tr>
<th>No</th>
<th>Key Observation</th>
<th>Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>By this time, I’m not taking any new rules in.</td>
<td>New players reach a certain threshold beyond which they cannot grasp any more rules.</td>
</tr>
<tr>
<td>2</td>
<td>It is very difficult to explain some game elements without enacting them.</td>
<td>Enacting is the only way you can explain some rules.</td>
</tr>
<tr>
<td>3</td>
<td>M is playing for N’s strategy.</td>
<td>If an expert player explains the rules too much, new player stops learning and playing effectively.</td>
</tr>
<tr>
<td>4</td>
<td>I’m playing only to play. It is too complex and coming this far, I don’t want to ask for any more clarifications.</td>
<td>New players endure a game they don’t understand the rules of too much.</td>
</tr>
</tbody>
</table>

Game 4 – Coup
1. B explains the rules again.

2. The game has only cards. Three cards each of 5 player types.

3. Duke - Assassin - Contessa - Captain - Ambassador

4. There is confusion regarding one player role that is not for the base game, it was from the expansion, quickly resolved.

5. M pointed it out, very observant of her to notice a very small symbol.

6. Confusing way of explaining things: B says “the goal of the game is to eliminate other player’s influence on the game. Cards give you influence.” INSTEAD OF SAYING “THE GOAL OF THE GAME IS TO MAKE PEOPLE LOSE THEIR CARDS.” SOME EXPERIENCED PLAYERS DIG COMPLEXITY.

7. Cards change round quite a bit, and it is important to know there are only 3 of each character, and when players lose their cards they place them face up on the table.

8. On your turn you pick an action. You do the action and as long as the action is not challenged or countered, your challenge will succeed. List of actions is explained. COUNTER ACTIONS AND CHALLENGES ARE NOT EXPLAINED AT THIS POINT, THEY ARE VERY RELEVANT FACTS AT THIS POINT.

9. Income 1 coin. Any character can do it.

10. Foreign aid. 2 coins if someone has a duke, they can counter you. CHALLENGE AND COUNTER ACTIONS MENTIONED AGAIN BUT “WILL EXPLAIN LATER.”

11. Questions and discussion on how counters work. I ASK ABOUT CHALLENGE, “I’LL EXPLAIN IN A BIT.”

12. Explaining about the Coup - unblockable action with 7 coins payment. DIFFICULT TO REALIZE THIS IS THE MOST IMPORTANT ACTION IN THE GAME.


14. Continuing with the player actions. Ambassador or Captain can both block stealing. THIS IS AN IMPORTANT POINT, NOT VERY WELL HIGHLIGHTED.

15. B enacts some possible game situations - they are too fast and don’t help me much. M SCREAMS “HOW CAN SOMEONE REMEMBER ALL OF THAT? YOU NEED TO BE SUPER SMART TO BE ABLE TO REMEMBER ALL THAT!”

16. 3 Players are asking about challenge. CHALLENGE, THE MOST IMPORTANT DYNAMIC OF THE GAME, HAS NOT BEEN EXPLAINED WELL ENOUGH.

17. Players are asking more difficult questions after B’s scenario enactments.
18. Game starts - N goes first.

19. There are still clarifications about challenge being discussed.

20. N is just asking a simple question, but B gives a long answer containing facts that are not required.
   THE TEACHER CAN COMPLICATE THE TUTORIAL IF HE LIKES THAT SORT OF THINGS.

   B CLARIFIES: WE ARE ASSUMING SHE HAD A CAPTAIN. AND S DOES NOT HAVE AN AMBASSADOR OR CAPTAIN.

22. I'm thinking aloud. I take two coins. S counters. I challenge he takes back.


   B CLARIFIES: ARE YOU CHALLENGING S HAS A CAPTAIN OR CHALLENGING YOU HAVE A DUKE OR AMBASSADOR? I DONT THINK THIS IS CORRECT.

25. N is proved wrong on challenging S, and she loses a card.


27. N performs an action, B asks for clarification and the action eventuates, but there is no learning. N sounds like she agrees because it is being explained to her, and I have no idea what happened.
   NEW PLAYERS WILL AGREE TO AN ACTION IF THEY DONT UNDERSTAND AND DONT WANT TO SEEK CLARIFICATION.

28. B is explaining something, and he has explained that before so goes normally you would do “da-da-da-da-da”.
   IF THE TEACHER GOES BLALABLAH, PLAYERS LOSE INTEREST IN THE POINT IMMEDIATELY.

29. N assassinates M. No challenge.

30. I take three coins. No challenge, the bluff goes unnoticed.

31. B does that as well. Reveals he could have challenged me but wouldn’t risk it as he had only one card left.

32. S steals. I reason on challenging, but do not for same reason as B.

33. 33. B thinks aloud for himself, guessing who's got what, I pretend to agree.

34. 34. S assassinates M. “We are still friends,” she says.

35. 35. B 2 coupes me, I’m out of the game.

36. 36. B consoles me, “that’s the game, coin economy,” if someone gets 7 coins, they can take out anyone.
B REVEALS A FACT: PEOPLE THINK DUKES HAVE A LOT OF POWER IN THIS GAME.


38. 38. M coups S.

39. 39. B assassinates M.

40. M IS OUT OF THE GAME BUT MENTIONS ‘HEY I TOOK A FEW PEOPLE OUT OF THE GAME ALRIGHT!’

41. 40. Game is over, S wins (?)

Discussion on if we are playing a new game. N is out. B has 15 minutes for his train. Rest of us agree to have a quick game.

<table>
<thead>
<tr>
<th>No</th>
<th>Key Observation</th>
<th>Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Instead of saying, ‘the goal is to make people lose their cards’ some players dig complexity.</td>
<td>Expert player’s tutorial can be biased by their style, this style can be convoluted.</td>
</tr>
<tr>
<td>2</td>
<td>Counter actions and challenges are not explained at this point, but they are very relevant facts at this point.</td>
<td>Expert player’s tutorials can miss certain important points in the narrative.</td>
</tr>
<tr>
<td>3</td>
<td>Challenge and counter challenge “will be explained later”</td>
<td>Tutorials have to be better structured through an engaging narrative.</td>
</tr>
<tr>
<td>4</td>
<td>I ask about challenge, “I’ll explain in a bit”.</td>
<td>New players do not have the freedom to understand the game as they like.</td>
</tr>
<tr>
<td>5</td>
<td>Difficult to realize this is the most important action of the game.</td>
<td>New players find it hard to differentiate between game critical and game play information.</td>
</tr>
<tr>
<td>6</td>
<td>This is an important point, not very well highlighted.</td>
<td>Tutorials have to be better structured, explaining important points.</td>
</tr>
<tr>
<td>7</td>
<td>M screams.</td>
<td>New players can get extremely frustrated with expert player’s tutorials.</td>
</tr>
<tr>
<td>8</td>
<td>Playing the challenge action, the most important dynamic of the game has not been explained enough.</td>
<td>Tutorials need to be better structured and have a clear hierarchy of information</td>
</tr>
<tr>
<td>9</td>
<td>The teacher can complicate the tutorial if he likes that sort of thing.</td>
<td>(1)</td>
</tr>
<tr>
<td>10</td>
<td>B. clarifies, are you challenging S as a captain or challenging you have a duke or an</td>
<td>N.A.</td>
</tr>
<tr>
<td>11</td>
<td>New players will agree to an action if they don’t understand and don’t want to seek clarification.</td>
<td>New players can lack confidence to resolve their queries by asking other players</td>
</tr>
<tr>
<td>12</td>
<td>If the teacher goes “blah blah blah”, players lose interest in the point immediately.</td>
<td>(1), (2), (6)</td>
</tr>
<tr>
<td>13</td>
<td>A revealing fact: “people think dukes have a lot of power in this game.”</td>
<td>(1) (2) (6)</td>
</tr>
<tr>
<td>14</td>
<td>“Hey I took a few people out of the game alright!”</td>
<td>New players don’t need to win to enjoy their first game.</td>
</tr>
</tbody>
</table>

Game 5 Coup Game 2

Game 5 - Coup game 2

1. Cards are distributed, game begins.

2. I take three cards. B does the same.


4. S steals from me. I don’t challenge.

5. B assassimates M. M challenges. B reveals assassin. M reasons, “I would have lost it anyway.” S says she could have revealed a Contessa, before challenging. B mentions he could have still assassinated her. How? She didn’t block B’s action. That’s why I was asking you! I would have lost it anyway. You made me do it after the action. B says he hadn’t figured it out before. M screams I didn’t think a double kill was possible. Recap, B says if she challenged she would lose a card, and his action still was in place. That’s why I was asking you! I didn’t hear that question. You just said if you can counter. That’s a new rule slipped in. There are no rules! You didn’t tell us there could be a double kill! If you challenge an assassination and there is another assassination I hadn’t put it in my head how that would play out. Oh sh*t! you are going to lose both your cards. I genuinely was not aware this could happen. M explains what she did and why. B agrees, but maintains he did not know the consequences. That’s why I asked! But said nothing about the fact of double assassination. You just said you challenged me, you didn’t ask anything! I did ask if it makes no difference. B 2 intervenes, says let’s pretend you did not do it. B 1 maintains I seriously did not figure out the consequences till you did the action. I intervene, let’s undo that action and shuffle the cards. Don’t worry about it, M says, I’m out.

DUE TO UNCLEAR RULES EXPLANATION, SUCH SITUATION CAN ARISE - THIS IS BAD FOR EVERYONE INVOLVED AND MUST BE AVOIDED AT ALL COSTS.
6. B continues. I’m sorry I didn’t tell you, I wasn’t aware it could happen. That’s why I ask asking you before doing that! I didn’t know that.

7. S plays his turn. I ask about my turn. S asks, oh did you not get a turn? I hadn’t got my turn, B skipped me, because it was M’s turn. But now B says oh I’m sure you got a turn and you did this. I am not sure if I did that this time or in my last turn. Things bad enough as they were, I did not argue.

AFTER ARGUMENTS, MISTAKES CAN HAPPEN IN THE GAME. ARGUMENTS CAN START THE SNOWBALL EFFECT.

8. Discussion on whose turn it is.

9. After some more confusion it is resolved that it’s my turn back again.

10. I play ambassador and shuffle cards.

11. B lets me do it, mentions he could have challenged but risk was high.


15. People aren’t talking too much.

SEEMS LIKE THE ARGUMENT AFTERMATH.


17. B mentions the ambassador exchange is interesting, I didn’t care what you had before, I don’t care what you have now.

WHATS THE POINT OF SAYING THAT?

18. B steals 2 coins from B 2, who blocks, who is challenged. B 2 calls B’s bluff, B is out. Parting words: A good game is a quick game.


NOBODY IS TALKING MUCH.

20. B is leaving, M thanks him for the game. B apologizes about the mix-up.

21. S is out of the game somehow, can’t remember now.


<table>
<thead>
<tr>
<th>No</th>
<th>Key Observation</th>
<th>Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DUE TO UNCLEAR RULES EXPLANATION, SUCH SITUATION CAN ARISE - THIS IS BAD FOR EVERYONE INVOLVED AND MUST BE AVOIDED AT ALL COSTS.

Tutorials have to be better structured.

AFTER ARGUMENTS, MISTAKES CAN HAPPEN IN THE GAME. ARGUMENTS CAN START THE SNOWBALL EFFECT.

Mood of the game once spoilt, stays like that.

SEEMS LIKE THE ARGUMENT AFTERMATH.

Nobody enjoys a game after an argument.

WHATS THE POINT OF SAYING THAT?

Nobody is talking much.

GAME 6 Settlers of Catan – 3 Players

1. Events Chronicle for Settlers of Catan 3-player on default game board.
2. Three players game, as this was the second game of the evening, I had finished the first game, and most of the other games were going on so there were few players available.
3. I find S and D, looking for a game and we start Settlers of Catan, my favourite game, and a relatively easy second game for a board games evening.
4. S had good experience at the game and played at expert level. D had known about the game but had never played it before.
5. We setup the game map and cards and tokens, and both S and I explain the game to D. S is leading the narrative with me interrupting from time to time to emphasize on some points and append some rules. The narrative takes about 10 minutes.

OFTEN IN EXPLAINING THE GAME, WE USE PHYSICAL TOKENS TO ENACT SOME SITUATIONS. IT WORKS BEST IF ONE PLAYER EXPLAINS THE WHOLE GAME, AS IF THERE ARE TWO PLAYERS EXPLAINING THE NEW PLAYER GETS CONFUSED.

6. While explaining some concepts, D is just nodding, and I'm not sure if he is understanding it all, eventually he says, “Let's start the game and I'll learn as we go.”

AFTER A SHORT LEARNING THRESHOLD, NEW PLAYERS PREFER TO START PLAYING THE GAME AND LEARN ON THE GO.

7. Its D's turn for the first settlement. S and I both are explaining how to get a good first settlement. We show him the options and the strengths and weaknesses of each. D goes first and takes a 4-6-9 stone-wood-brick. A good choice.

IF OPTIONS ARE LAID OUT BEFORE A NEW PLAYER AND THE DIFFERENCES EXPLAINED, THE NEW PLAYER MAKES A CORRECT CHOICE.

8. Next is my turn, I take 5-8-10, sheep-stone-wheat.
9. S takes 4-5-8 stone-wood-sheep and 3-4-8 wheat-brick-stone. S is in a strong position, covering all resources and having two numbers for stone.

10. Next on my turn again, I take 5-6-9 wood-wood-sheep. I have no options but to go without brick.

11. D's second settlement is 8-10 sheep-wheat. This is a tough one. D goes for the remaining two resources as we had told him to ensure a healthy flow of all resources. But he gets only two numbers more for his number palette. He also gets a 3:1 port, so it might work out for him, but this is an advanced strategy.

ADVISING ON ADVANCED MOVES IN THE FIRST FEW TURNS FOR THE NEW PLAYERS MAY NOT WORK WELL, AS THEY NEED EXPERT GAMEPLAY THROUGHOUT THE GAME.

12. Game begins through the rolling of the dice. D is happy we've begun.

WHEN THE GAME BEGINS, THE NEW PLAYERS ARE “REALLY” INVOLVED.


14. I secure a 2-9-10 brick-brick-wheat spot to start some brick making. S cuts me off to go for the stone port. I don’t mind as it was not a priority for me.

IF OLDER PLAYERS PLAY THEIR NORMAL GAME AND DO NOT CONCERN THEMSELVES WITH THE NEW PLAYER'S ACTIONS, NEW PLAYERS CAN GET OFF ON A BAD START.

15. D's actions finally reveal his strategy. He has bought two development cards with the resources he should have spent on expanding.

S AND I STILL DON'T INTERVENE.

16. D opens up a knight card, and blocks S. And in another turn he does the game thing again.

D IS THINKING MORE ABOUT THE DEVELOPMENT CARD STRATEGY, AND IS WRONGLY FIXED ON THE KNIGHTS ACTIONS.

17. S asks correctly, “why are you burning your knights at this point of the game, when you don’t have to?” D answers, “You will run away with the game otherwise.” S explains, “Sure it looks like that, but things can change. You shouldn’t burn your resources on defence.” What S meant was ‘you shouldn’t unnecessarily attack’

18. The game goes on, but by now S and I have developed healthy momentum for earning and spending, while D is not getting enough resources as he has not expanded,

A SLOW GAME DOES LITTLE TO MOTIVATE A NEW PLAYER.

19. I am not getting enough resources to upgrade the village to a city, so I start buying development cards.

20. S is the clear board leader, with 6 points on the board. I'm on 4.

21. I go for the longest road, and take it making 6 points. D thinks of challenging me. S says, “You shouldn’t go for the longest road now, as mathematically, Naman will always have more resources to keep it.”

TELLING NEW PLAYERS THAT THEIR STRATEGY IS NOT GOING TO WORK, DEMOTIVATES THEM EVEN MORE.
22. Soon enough, I take the largest army as well, with the development cards I’ve been buying. D can’t have that we well now. I am on 8 points, and buy one development card, the victory point, going to nine.

23. I remark that it’s in S’s best interest to help D with the road now, to give me competition. D is least interested in the game now. None of his strategies worked. He tried three: going for development cards and attacking a player right from the start of the game, going for the 2 points army, and a half-hearted effort to go for the longest road.

24. S, with three upgrades is earning lots of resources. I’m worried about the longest road now.

25. Enabled by the stone port trades, S takes bricks from stone exchange and connects his road taking the longest road away from me, and wins the game.

26. S comments on D’s poor performance, and consoles him by saying that he has had worse games and some games just work out for you. D does not buy it.

REASSURING A NEW PLAYER THAT HE HAS PLAYED BADLY JUST BECAUSE OF TOUGH LUCK DOES NOT INTEREST THE NEW PLAYER.

Game afterthoughts: S and I could have helped D have a better foundation during the initial settlements placement, and in the subsequent actions to expand his game. We left him alone, and D was left to make his own strategies which were not well informed because of his lack of experience with Catan game mechanics. This resulted in a bad game experience for D. What would have helped D is mine or S’s intervention in the early part of his game, guiding him towards a better strategy.

<table>
<thead>
<tr>
<th>No</th>
<th>Key Observation</th>
<th>Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>OFTEN IN EXPLAINING THE GAME, WE USE PHYSICAL TOKENS TO ENACT SOME SITUATIONS.</strong></td>
<td>Some game rules can only be explained through enacting them.</td>
</tr>
<tr>
<td>2</td>
<td><strong>IT WORKS BEST IF ONE PLAYER EXPLAINS THE WHOLE GAME, IF THERE ARE TWO PLAYERS EXPLAINING THE NEW PLAYER GETS CONFUSED.</strong></td>
<td>New players can get confused if there is more than one source for learning.</td>
</tr>
<tr>
<td>3</td>
<td><strong>AFTER A SHORT LEARNING THRESHOLD, NEW PLAYERS PREFER TO START PLAYING THE GAME AND LEARN ON THE GO.</strong></td>
<td>New players prefer to start playing the game and learn as the game progresses than to know all the rules before starting.</td>
</tr>
<tr>
<td>4</td>
<td><strong>IF OPTIONS ARE LAID OUT BEFORE A NEW PLAYER AND THE DIFFERENCES EXPLAINED, THE NEW PLAYER MAKES A CORRECT CHOICE.</strong></td>
<td>If options are laid out before a new player and the differences explained, the new player makes a correct choice.</td>
</tr>
<tr>
<td>5</td>
<td><strong>ADVISING ON ADVANCED MOVES IN THE FIRST FEW TURNS FOR THE NEW PLAYERS MAY NOT WORK WELL, AS THEY NEED EXPERT GAMEPLAY THROUGHOUT THE GAME.</strong></td>
<td>If experienced players give complex advice, it does not help new players because they may not understand the reasoning behind it.</td>
</tr>
</tbody>
</table>
WHEN THE GAME BEGINS, THE NEW PLAYERS ARE “REALLY” INVOLVED.
New players just want to start playing the game.

IF OLDER PLAYERS PLAY THEIR NORMAL GAME AND DO NOT CONCERN THEMSELVES WITH THE NEW PLAYER’S ACTIONS, NEW PLAYERS CAN GET OFF ON A BAD START.
New players need guidance on game strategy.

S AND I STILL DON’T INTERVENE.
Experienced players can mislead new players on the wrong strategy.

D IS THINKING MORE ABOUT THE DEVELOPMENT CARD STRATEGY, AND IS WRONGLY FIXED ON THE KNIGHTS ACTIONS.
New players can follow an incorrect strategy.

A SLOW GAME DOES LITTLE TO MOTIVATE A NEW PLAYER.
New players can be de-motivated if their strategy does not work well.

TELLING NEW PLAYERS THAT THEIR STRATEGY IS NOT GOING TO WORK, DEMOTIVATES THEM EVEN MORE.
New players need a fairly good strategy in their first game.

REASSURING A NEW PLAYER THAT HE HAS PLAYED BADLY JUST BECAUSE OF TOUGH LUCK DOES NOT INTEREST THE NEW PLAYER.
New players want a sense of control over the game.

GAME 7 Settlers of Catan

This is the debriefing of the Catan game played at the royal standard, part of the Eurogamesmeetup.

1. Played Catan with 4 players. One of them was an experienced player and two were a little familiar with Catan although they had a lot of refreshing of the rules to do before starting the game.
2. Players clockwise from me were B, S and D. D was the experienced player, B and S were new to Catan. S had played it only once before, while B played more than that, but a while ago so was out of touch with the rules.
3. I explained the game components, rules and goals, with help from D who agreed, appended and rephrased some rules now and then for the new players.

AS I WAS EXPLAINING, NEITHER OF THEM INTERRUPTED ME. THEY WERE JUST LISTENING INTENTLY. NOT SURE IF THEY WERE UNDERSTANDING OR JUST AGREEING TO START THE GAME AND LEARN AS WE GO OR BORED. LATER THEY MENTIONED MY EXPLANATION WAS GOOD. NO ONE ASKED ABOUT THE MANUAL. DURING THE GAME THEY ASKED VERY FEW QUESTIONS, MOSTLY ABOUT THE GERMAN DESCRIPTIONS ON THE DEVELOPMENT CARDS AS THE GAME WAS IN GERMAN.
4. Laid out the board, the board was interesting very brief analysis of the board: the key resources brick and stone. Brick was on 2, 5, and 11. 2 and 11 are bad, that leaves only 5 for brick.

5. Stone was on 9, 9 and 12. So this game was not going to be about stone very much, about brick, maybe.

6. 6-9-10 sheep-stone-wheat was the first settlement I went for, as I started the game after rolling the highest number on the dice.

7. Then went on clockwise from me, next was B, S and D, and for the next turn D, S and B and then it was my turn to place the second settlement. I had very little options, as 4 players were playing on a 4-player board. If 3 players are playing then it gives you more room. I did not have wood and brick, and the only place they overlapped was 3-4-11 wheat-wood-brick.

8. Clockwise from me the placement strategies: B: went for 6-3-11 sheep-wheat-sheep and 4-9-11 wheat-stone-sheep. B did not have wood or brick. Very surprising. He was not familiar with the game so he wouldn’t have known. Wood and Brick are essential to start the game and go somewhere.

9. S: got 3-5-8 sheep-brick-wood, and 3-6 sheep-wood with the wood port. So S did not have either stone or wheat. Very poor placement by guys not familiar with Catan, in the initial settlements phase.

   THIS IS WHERE THEY WOULD HAVE REQUIRED ASSISTANCE. I DID NOT GET AROUND TO EXPLAINING THE BASIC PLACEMENT STRATEGIES TO THEM, NORMALLY I DO, THIS TIME I FORGOT ABOUT IT, AND D DID NOT GUIDE THEM. I WAS AWAY AS I WAS THE FIRST AND THE LAST IN THE SECOND ROUND, SO I WENT AWAY TO GET SOME BEER, AND D SHOULD HAVE ADVISED THEM, BUT HE DIDN'T.

10. D comes across as very competitive from the start of the game.

11. D got 2-4-6 brick-wheat-wood and 4-8 wood-sheep but no stone. A major lack of insight as there would have been options available for stone but he did not go for it.

12. D was the first to build a second settlement on a brick port which was not a very good move because he had brick coming in on 2 which doesn’t roll very often.

13. As the game progressed I made two settlements on 8-10 wood-wheat and a 3:1 port which was just brick on 11, mainly for the port.

   BOTH THE NEW PLAYERS UTILIZED THE PORTS VERY WELL, AND TRADED VERY WELL IN THE GAME.

14. Both these guys, S and B for some reason, both of them thought that they had to place their settlements very near to each other. They should have gone for settlements further apart.

   INTERESTINGLY, BOTH NEW PLAYERS ASSUMED THE TWO INITIAL PLACEMENTS HAVE TO BE NEAR EACH OTHER. THIS ASSUMPTION COULD HAVE BEEN VERY EASILY BROKEN BY EXTERNAL ADVICE.

15. S's expansion was blocked on both sides, I blocked it through my road early in the game, and D had built his settlement on the other side.

16. And then as the game progressed S was the first to get the longest road, but there was no way he could keep the longest road for long.

   NEW PLAYERS OFTEN GO FOR THE LONGEST ROAD MOVE.
17. There was this road battle between D and B. B prevented D go for the longest road, which blocked his expansion and prevented D from going for the longest road. If D had got the longest road it would have been very difficult for anyone else to have gone for that.
18. In these longest road battles, I played the warmonger and got the longest road for me silently.
19. B was the first guy to get two knights, and he was trying for the largest army but couldn’t get it despite getting another card.
20. This was also lucky for me, as my third card was a knight so I got the largest army card.
21. Timely execution of the Monopoly card, I rolled 4 and a lot of players got wheat, and I ended up robbing six wheat from them all.
22. Everyone traded well, even the new players. They knew well enough which resource was how much desirable and important at each stage.
23. In the end, the road was taken by me and it was long enough to deter competition. Although B played very well to get the longest road for a while. He didn’t have wood or brick but ended up with seven roads still, which was pretty good.
24. S was blocked on the ocean, but he had a wood port and he upgraded the 8-6 settlements on wood. He had two 8-upgrades on wood. Very well played for the wood strategy. A long-term strategy it was, he would have done very well if it was a 13 points or 15 points game.
25. D, it’s not clear what his strategy was. He lost interest after he couldn’t go for the longest road early on as he was blocked by B.
26. D’s personality was most fun to play with, I would say. Very competitive, and a good person to beat.
27. Personality analysis: B was smartest of the lot I would say. Despite having the poor locations, he adapted very well. Didn’t ask a lot of questions, but executed a lot of basic strategies, like going for the development cards because he had no other options, rightly going for the road at the crucial moment.
D WAS NOT TOO HAPPY TO NOT WIN, HE DIDN’T HELP WITH PUTTING THE GAME BACK IN THE BOX. DID PARTICIPATE IN THE AFTER-GAME ANALYSIS BUT WAS KEEN TO LEAVE.
28. S: S adapted pretty well with the upgrades. Didn’t go for the longest road, because there was no point for the longest road, but he should have gone. He could have had 10 roads link, but it’s not clear why he didn’t go.
S HAD A MENTAL BLOCK FOR THE LONGEST ROAD. HE COULD HAVE GONE FOR THE LONGEST ROAD. HE SHOULD HAVE. IF IT WAS SUGGESTED TO HIM HE WOULD HAVE.
29. The game took about 90 minutes. Good time. Overall a very healthy game. No one was leading throughout and everyone was interested more or less, good game considering two players were fairly new to Catan.
30. The game analysis was deep and thorough, and went on for a considerable amount of time, as we were packing up the game.
NEW PLAYERS PARTICIPATING IN THE POST-GAME ANALYSIS IS A GOOD SIGN OF THEIR INTEREST IN THE GAME.
Game 8 Catan Observations:

1. M went first, then J, then me, then R.
2. M was bored when I was explaining the rules, and wanted to start the game and learn while playing.
3. R and M were new to the game.
4. They didn’t get the dice, probability concept at first, why 5-6-8-9 are good spots.
5. They didn’t get the should-cover-all-resources part of the initial setup.
6. What J did: was playing nice in the beginning, he could have blocked R’s road, but didn’t because it was R’s first game. Then half way in the game, decided to stop being nice and blocked him. J also gave false advice to M... M could have built a settlement in the middle of J’s road and would have thus broken it, and J didn’t tell her about that.
7. M sought help from this Chinese guy Ronald, who was very choreographed in his gestures and considered himself a master of Catan. He didn’t tell M about the settlement in the middle of J’s road and that’s how I knew he was not a master of Catan. They took hours to discuss one move and act. When I bought a development card and looked at it, and put it away, Ron said “Nice poker face.” I rolled my eyes.
8. M sought help from this Latino guy Enrique, who promptly pointed to the settlement in the middle of J’s road. When M consulted Ron again he refused to acknowledge his lapse of observation and explained why that settlement was a bad idea, and why M should be going in the other direction, wrong on both accounts.
9. That’s when I had enough of passive observation. I explained things, “M, you should build the settlement here. For the longest road it’s J vs. R. By building the settlement there you will break J’s road and he will be out of the race. We should want R to keep the road because 1. R has built all settlements, and can only upgrade, and 2. R doesn’t get any stone to upgrade, which means his game is stuck here, which is what we want. R stuck on seven, and J out of the road race.”
10. No one was going for the development cards, and so I bought them all, and won the game with 6 points on the board, 2 for the army and two Victory points.
11. J pointed out that I was very smart throughout the game to divert people’s attention to him as the board leader. R and M didn’t care about losing the game. They were happy to finish it. I was too happy to win to care about their interest in the game.
12. I wasn’t going for the win and we had only later settled on 10 points win for the game. Earlier we decided to have a 13 pointer because we were playing a large board with only 4 players. We cut it short to finish it quicker because there were two people wanting to play a next game.
13. Dice: 3,5 and 11 rolled a lot in the beginning. 8 didn’t roll enough, neither did 4 or 6.
14. I was white, M red, J brown and Rochre. White works as a good camouflage.
15. J had the best starting positions: 4-5-6-6-9-10 and covering all resources.
16. I had 4-5-5-8-9-10, also covering all resources.
17. R had 3-4-5-6-8-9 without Stone.
18. M had 6-8-9-10-12 without wheat.
19. R and M were first/last to place settlements, thus they didn’t have all resources, and J and I were in the middle, so could secure good ones.
20. R, predictably went for the road. In my long years of playing I’ve learnt that you should never
go for the road, you catch everyone’s attention, and there is little security. In the second half
of the game, it’s easy to get the road because people are getting more resources, and
there’s a chance of getting the two-road card. J also went for the road... which he should not
have that early in the game.

21. For me, I can see the game now in three phases, the same three phases for everything I
guess: sh*t catches your eye, sh*t jumps up, and sh*t hits the fan. In phase 1: you ‘go with
the flow’ and only two things can happen: the flow carries you where you want to go, or it
carries you away from it. The flow, obviously means the rolls of the dice, discarding
resources, getting blocked, things where you are the victim of circumstance, without
‘deserving’ it. If the flow is good, you don’t need to worry about the game, and can just
enjoy it. If it is not, you need to worry. In both cases, you need to deal with the situation
with better mental prowess. In phase 2: you are hard at work, trying to secure your future,
with or without the flow. If the flow assists you, you are most likely to win, if it doesn’t, you
may still win, but wisdom is in knowing when to give up. And giving up at the right time is a
smart thing to do. << Made Flow Chart >>

22. As it was a game with two new people, I had the boring task of explaining it to them, and
knew if I win too easily they would not be interested in the game, so there was little for me
in the game.

23. I could only win because of the 100s of times I’ve played Catan and can execute difficult
manoeuvres and know things from three steps back and forward.

24. The monopoly card that I used was the last nail in the coffin.

25. I couldn’t contain my excitement while approaching winning, and everyone could make out
that I was going to win, I should have had a better ‘poker face’ but after a hard day’s work
and feeling sick in cold miserable Melbourne winter, when I’m happy I’ll rub it in your face,
sorry.

R was on for another game. M had to leave, and her friend Sabine took her place. J was ambivalent
as ever. We looked for a new game, before playing Catan again. J said he had got power grid, and we
should try that. I seconded that and R and Sabine didn’t mind, and so we started on that.

Game 9 POWERGRID

Game POs Powergrid:
1. R left within a few minutes of the new game.
2. J did a terrible job at explaining the rules.
3. N from the other table was passing by and knew the game so he jumped in also to teach the
rules.
4. R had enough of confusion, and left at that point.
5. N took his place.
6. S replaced J.
7. So now the players were: N, Sabine, S and me.
8. We started the game, and I didn’t know what we had to do.
9. Mid-way in the game I learnt all this.
10. Each turn has three phases: buying the power stations, buying resources and building cities. The mega-factor of the game is powering the cities, which can be done by spending resources.
11. Power plants have different prices, acquired by auction, and different capacities of resource consumption and power generation capacities.
12. Resources are coal, oil, garbage, uranium and wind that generate power. You cannot buy wind, it’s free.
13. You can buy more cities if you can pay for the connection and establishment charges.
14. At the end of each turn, you earn money depending on how many cities you can power (not build), at this point you spend resources.
15. Resources are then replenished, (there is a mechanism for changing the value of resources) and turn order rearranged (there is a mechanism to ensure fair play) and turn starts again.
16. To recap: power stations, resources, city blocks, power up! Spend resources, make money.
17. Simple enough. Basic counting. The player with that powers 17 cities first wins (in a 4 player game).
18. If two players reach that spot, the tie breaker is the money they have.
19. I won the game, rubbed it N’s face a little, and had the tremendous steak of 3 new games won, 2 catan won, 1 new game lost and 1 new game abandoned. Good stats, need to keep them so.
20. The map was Germany, but can be loosely based on any geographic map.
21. The graphics were not suitable for an electricity based game: the pipes carrying cables were too water-pipe like.
22. Tokens: money was notes of $1, $5, $10, and $50 and resources: oil, coal, uranium, garbage, and towns of 6 colours.
23. I like this game better than Antike. K2 is like a kid’s version of Powergrid. Has some similarities to Chicago Express.

GAME 10 K2

Game experience: K2

Game factors: weather, steep climb, and oxygen. 1-5 players, about 60 minutes.

Each player directs a team of 2 mountaineers who in competition with other teams are trying to reach the peak of K2, and survive until the end of an 18-day expedition.
Game board is two flavours, and weather is for two seasons, therefore you can have 4 game conditions to play:

<table>
<thead>
<tr>
<th></th>
<th>Summer Season</th>
<th>Winter Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier side to climb</td>
<td>Easy</td>
<td>Moderate</td>
</tr>
<tr>
<td>Harder side to climb</td>
<td>Moderate</td>
<td>Difficult</td>
</tr>
</tbody>
</table>

K2 Observations:

1. Players, there were 4 players. Me, Bilbo (not real name), C, and Teacher-man.
2. Bilbo owned the game and was very happy to teach it, a bit annoying as well.
3. C and I were new to the game, Teacher-man was familiar with it.
4. Two climber tokens and two climber marker tokens. (a bit of a waste, as the mountain is clearly marked for altitude)
5. Player board with acclimatisation marker, 1-10. Less than one = player death.
6. Tents that the climbers can set in the mountains and gain APs.
7. Weather, under 6000 base camp: always good: 6000-7000, 7000-8000, and above 8000, white line means frosty and number indicates the loss of acclimatisation points.
8. Random deck of cards: movement points and acclimatisation points, green and blue, respectively. (Vertical movement points are 1/3 for ascending/descending.
9. Hand cards: first move: pick up 6, choose 3 to play. You can either move, or acclimatize (green or blue), you can split up the (integer) numbers as well.
10. Next turn, pick up three new cards from the deck, so you have 6 cards (3 new and 3 old) and pick up 3 of them to play.
11. C is spending a lot on movement initially, advancing ahead of all of us.
12. Red-girl is balancing the two, my early moves are similar to C, teacher-man and Bilbo are playing by the book.
13. Bilbo is explaining the game like we are first-graders, and teacher-man jumps in from time to time to append the rules.
14. As it was a 4 player game, 3 climber tokens per spot were allowed. This number is lower if there are 2/3 players.
15. I missed the “ropes” linking different spots. Only linked spots can be moved onto. There are two paths without rope links between them, and I thought you could jump from one spot to another, but you couldn’t.
16. Base camp, you gain acclimatisation points for doing nothing, but the catch is that at the end of each round if your players have more than 6 ac points, they lose those points.
17. Moved on to 6000-7000 m level without problems. Now you lose acclimatisation points on a few spots. C lost the first ac points when climbing on the leftmost side.
18. If you play the most number of movement points, you have to take a risk token which will subtract from your hand. Risk tokens are value 0,1 or 2. I didn’t understand the risk token factor.
19. Now the strategies come to play. Teacher-man plays the movement strategy, but with only one climber.
20. Bilbo is balancing both of them. C pitches the first tent. I’m not being too adventurous, focusing mainly on oxygen points. I don’t want to be the first player whose climber dies.
21. I missed the weather factor, but on a higher spot near the 8000 point I was fortunate to have good weather, as Bilbo pointed out.
22. C went down to prevent climber death. Teacher-man lost a climber above 8000 meters, a big loss to his strategy that cost him the game, he was visibly sad.
23. I won the game for no smart moves of my own, my little contribution was the risk-averse strategy.
24. “I didn’t do enough to deserve to win” feeling.
25. You have learnt strategies to make you want to play the next game; the “Next Time” feeling.

GAME 11 REX

REX [Twilight Imperium Universe]
(Re-imagined version of Dune. Set in Fantasy Flight’s TI Universe, 3000 years before the events of TI, REX tells the story of the last days of the Lazax Empire)

- Designed in 2012
- 3-6 players
- ~ 2 hours to play
- Negotiation / Politics / Sci-Fi / War
- Direct Control / Influence
- Hand Management
- Alliance
- Racial Powers
1. A – owns the game, low voice, didn’t explain it very well; losing in most of the game; suddenly could win at the end.
2. J – least willing to play, spent a lot of time wondering how he got involved in the game in the first place, whining about the complexity of the game, not making an effort to learn.
3. Me – couldn’t get the metaphors; was going well in the start, but then wasn’t going to well, allied with C (Turtles)
4. C – knew the game but was too reluctant to explain it repeatedly, said things like “you’ve asked me this before”
5. Blue Shirt guy – got money for his strategy cards; average player, good to play with.
6. Black Jacket guy – was losing, got focused, beat C-Me alliance, won game because of loss of strategy cards I think.
Appendix III

Notebook Pages
Note: Some images are of 2-page spreads and some of single pages. All images have been resized for consistency and there are no overlaps.
Check in the App tonight:
1. If you transparency holds
2. how fast feedback tracks
3. check for cube textures.

Create virtual button in Unity Editor:
1. Each VB attached to an existing image target
   - translate to scale the button
   - name the VB
2. Handle events associated to the VB
   - by implementing the IUnityButtonEventHandler interface
   - for methods:

    PHYSICAL INTERACTION

    TOUCH A NODE > SHOW COMPLEMENTARY NODE.

    Because people can easily differentiate between numbers.
class Calculator {
    public void add(int a, int b) {
        int c = a + b;
        return c;
    }
}

Seqn on 20 July 2013

User Meeting Summary.
Chen forwarded design inputs for map augment.
1. "Good" spots -> NDCS Headline
2. Photo References -> Resources highlighted

1. (Bob) "cheap"
   (3) "spare" etc.
   10, 10, 10, 10
   (5) (2)

2. Bill Price "good" spots:

Slide from top
Slide back top
Pan from top
Plain back top
Read from top
Read back top
Non-apply from top
Non-apply back top

Week 6 Contin

181
Not enough help.

Read Patterns

1. First
2. Good Spots.

Jane (other code)

Simplified Map (print)

4. Moves decision tree

Map part. Detection vs. W X

Color animation.

email Stefan about camera.

Good Spots on the

Photoshop canvas, make it bigger.

Have more detail at hands.

+ bigger photo.

What

Board

Shape

Word

Stone

Monday, August 5th 2013
6:36 PM, Lost, Level 4.

Email

called 4 us

B cleaned up RM1 initial. 2000 offers (about)

6:08 pm. 18 word files in shapes most folders.

8-12 move. 15. I'm on a meal.

8:15 now. What happened?

morning. In the software tomorrow as well.

and think of virtual buttons in physical space.

Slide button.

Play button.

2-12 hammer.
**184**

**Page 52 - Camera ready paper for proceedings**
- Paper due on August 15
- No corrections
- Submit to electronic author account

> Early submission must be done by this date.

- Make the final submission.
- Final PDF must be submitted.
- Make the official version.
- Submit the final manuscript.

**Paper 52**

- Camera ready paper for proceedings.
- Paper due on August 15.
- No corrections.
- Submit to electronic author account.

> Early submission must be done by this date.

**Note:**
- Early submission must be done by this date.
- Make the final submission.
- Final PDF must be submitted.
- Make the official version.
- Submit the final manuscript.

---

**Page 184**

1. Pick a red number.
2. Pick the highest value of the number(s) above.
3. Pick the highest number 1 or 2 of the two numbers.

**Rules:**
1. Spot for 0.
2. Spot for 1.
3. Spot for 0.

- 0-5-11: Stone - Brick - Wood
- 5-9-10: Wood - Stone - Brick
- 3-6-9: Stone - Wood - Brick
- 1-6-10: Wood - Stone - Brick
- 4-5-10: Wood - Stone - Brick
- 2-4-11: Stone - Brick - Wood

**Testing:**
- Start with 3.
- How good is this spot?
- Can this spot take up the whole screen?
- Consider the impact.
- Your next spot should be chosen.

**Note:**
- Early submission must be done by this date.
- Make the final submission.
- Final PDF must be submitted.
- Make the official version.
- Submit the final manuscript.
OK, this is it now. Stop mucking around and finish this. What is the sales pitch? An interactive manual for new players.
> When you test it, don't expect people to play the whole game. Exposure to old players and new, and have semi-structured interviews.
> You are doing 3 maps, to make the design scalable.
> ports, augment > resources linking models > citizen, good spots
> world, good physical simulations.

The map has 3 spots that trigger conditional information:

<table>
<thead>
<tr>
<th>Spot</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Event Type</td>
</tr>
<tr>
<td>2</td>
<td>Event Effect</td>
</tr>
<tr>
<td>3</td>
<td>Event Location</td>
</tr>
</tbody>
</table>

The red square [A] wins internal buttons that triggers augments on a different image target.

The image target > with VB.

```
+-------------------+
|       |       |
| Event Type | Event Effect |
|-------------------|
| VB Image |
```

Therefore, each image target has a virtual button (that has a custom handler script) that triggers a game object on a different image target.

Can this work?

0. Begin a new project. Fonte
1. Map Tiles
2. Map: Create Map To Tile
3. Print & Sketch

Check if any event handler can augment 2nd card.

"Game does not exist in the current context," it says.

"And do all visual boost and augments have to be on the same image target?"

OK, well think about it. Finalize the map files and print & construct > make sure there are no more silly hurdles that make them anyway. Now.

Get 3 sets of buildings, only need 4 above street & above.

- High building / good spots
- 10 numbers
- Full-page instructions
Now, at 11:00 pm, the code:

- Make all nCubes (221) vanish
- Make all cubes (212) vanish
- Make all harbinger walls

After

26 Code, identify all these elements:

- 42 virtual buttons: no need to name them, as have been named in most dilem.
- 24 flat cubes
- 24 number cubes
- 18 bars maps

Now, make all flat cubes are C1 C2 C3...

Now, all number cubes are n1 n2 n3...

Done.

- Remember all flat cubes are C1 C2 C3...
- And, all number cubes are n1 n2 n3...
- 24 each.
Handbook

User Interface

Program a mouse event
in unity

10th September

1. Number palette: 3, 4, 5, 7, 9, 10, 13
2. Paint layers: RVP-3
3. Object detection: X

Steps:
1. In a 3D animation
2. 5 - 20 frames
3. 1 second
4. 1 frame per second

Texture:
- Wood: 1, 8, 10, 13
- Back: 4, 6, 12
- Stone: 5, 15, 16
- Sheep: 2, 7, 13, 14

In total, all 51 and Scale all NCBO n1-n2a
all n2b
Phone Program
1. correct the drop-down cards
2. correct More Info cards display text as card itself and more info on bottom

Map Augments
1. Number Probabilities
2. Big good spots
3. Resource Importance Hierarchy

4. Combinations
5. 6-step tutorial
   a) 5 Resources
      i) Nodes for villages
      ii) village upgrades to cities
   b) Numbers - farm resources
   c) Build & buy speed resources
   d) Earn more - all roles
   e) Assign any card with smartphone

PLANNING
1. Resource: Wood
   a) 1 node
   b) Build 2 new towns & 2 new roads
   c) Build & buy speed resources
   d) earn more - all roles
   e) Assign any card with smartphone

WHEAT
1. Resource: Wood
   a) 3 nodes
   b) Build 2 new towns & 2 new roads
   c) Build & buy speed resources
   d) Earn more - all roles
   e) Assign any card with smartphone

DOMINOS
1. 4:30 pm 10th September 2018
2. DOMINOS 1.45
3. 20000
4. 0 P.A. finished!

Augment - VB Augment
1. Tweak + More
   a) Tweet + More info
   b) Tweet + More info
2. Environment Cards
   a) Tweet
   b) Tweet + More info

Create a new project, then one that I created, work on it.

Upload the new photo three times, download whole database.

Show block the image (go to next card set)

Add Tumblr + Virtual buttons + More info.

Make VB Event Handler

Make Card-Manager

Figure out size for script.

12 cards with 4 sequences + 4 notice

Run program + 20 + 1

TO DO
1. Add Virtual buttons
2. Figure out size for script
3. Run program + 20 + 1

More Info
1. 2 facts
2. 2 facts
3. More Info
Map C1 C2 C3
Cards ... C10

C0 - Base
C1-4 - Minor camps
C1-5 - Upgrade cards
C1-2 - Sound cards
1. Summary
   2. Notes
   3. Learning
   4. Naming
   5. Teaching

Goals
- Command
- Hole Walker
- Head of Skin
- Journal
- Lesser Common
- Night Eye
- Falling to the Moon

[Diagram]

- Photoshop Map 1 x with mark and assistant
- Open file
- Delete all WPS file button
- Make buttons for 1-2-3-4-5-6.
- Place
- Save
- Copy & Paste
- Stick

[Program - Map]
> Make layers on采访 position > summary
> Arcade
> Make animations for the 2-3 villages etc.
> If you get time - make animations

For C1-3 in the
- Major has print
- Underline C1 done process
- Try not internet

END OF PROJECT
I. Map Required
   1. Fully working map of C1
   2. Fully working map of C1
   3. Fully working map of C1
   4. Fully working map of C1
   5. Fully working map of C1
   6. Fully working map of C1
   7. Fully working map of C1
   8. Fully working map of C1
   9. Fully working map of C1
   10. Fully working map of C1
   11. Fully working map of C1
   12. Fully working map of C1
   13. Fully working map of C1

II. Phone Augment
   1. Cards come from higher ups
   2. Change position of Week Log...
1. All do not active
2. Demand Nodes: all active
3. Fully working options: skip down to good ones

Scene 1

Scene 2

Old program

5 Resources on the map
1. Sandstone 2. Sandstone ruby
3. Mud 4. Mud labels

Notes

- This is where you build a village
- Remove "villages upgrade to cities"
- Check alignment

Scene 2a
- Gaming - th 3
- Where 5 in realistic - thin
- This village can't - t 4 a
- Add 1 brick - t 4 c

Slide 1
- 6 slides

Slide 2
- Notes
  - It is a work where you build a village
  - You need a budget
  - Fix tool needs
  - Upgrade to items

Slide 3
- Earning
  - When 5 need the village will change / add

Slide 4
- Building
  - Bring the book
  - 0000 to build a village
  - 0000 to upgrade a village

Slide 5
- 50 objects
  - AR demo
  - 1. Map of slides 2. Ed, all animations
  - 2. Flashcard particle, EP
  - 3. Phone program

This is an experiment in an AR.
Using AR technology in a social, multi-human interaction with goals and actions.
Using AR to replace the older mediums of game manual to published materials.
I'm not sure what the map design is about. Better highlight some areas with red ink. Very good. Well done. Useful. Comments are turning into conversations. Good. I like it. Approach a company. Looks good.

How to conduct user research using interviews

Need for

Extraction Structure

Chapter 1 = Exception of whole
Abstract = TAX
Data = done is good, but poor ends.

Where else can I publish? Do CAI

A. Notes

Node layer

Resource layer

Endings

Map is only connected with formal numbers.
1. Resources:
   - 
2. Nodes:
   - 
3. Overlay:
   - 
4. Production:
   - 
5. Overlay:
   - 

Scene 1: Resources

There are five resources on the map. Points to any are tied to know more.

Name, Card, Importance:

- 1.5 - Medium
- 2.0 - High
- 2.5 - Very High
- 3.0 - Very Very High
- 3.5 - Exceptional

Wood on Grid Importance:

1. 12 - Very Low
2. 11 - Low
3. 10 - Medium
4. 9 - High
5. 8 - Very High

Scene 2: Nodes

Overlay:

Overlay:

Scene 3: Production Overlay

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:

Overlay:
Appendix IV

Documentation from Test Sessions with Users

Part 1: Interview with Test subject after the Pilot Study
Part 2: Testing AR System with Users
Part 3: Testing AR System with Experienced Users
Part 4: Observations and Notes during players’ interaction with Catan-QuickStartAR
Part 1: Interview with Test subject after the Pilot Study:

This interview was conducted after the pilot study with subject N.

Some questions to reflect on the 3 game sessions. How was the first game for you in terms of learning the concepts from the manual and by asking other players?

Hardly used the manual. Got most of the help from the other players to get to a speed.

So when you were explained the rules of the game before starting and then there were some things that you had to ask other players during the game.

Yes. That’s correct. There were a couple of things i had to ask multiple times to reinforce the learning. Including not having clarity on some things until some other player played their turn for the point to be reinforced. So it was continuous learning till the end of the game, and at no point I felt in full control of what the rules are.

Tell me more about the using the manual. You didn’t use the manual at all, did you think of referring to it?

Didn’t use the manual, had a glance at it, but I’m generally not a manual person.

During the game you asked clarifications only on two or three topics. Was that because everything was new. Or was it because those were the only things you didn’t know?

That was because everything was new, and it took me almost the whole game to firstly understand how others play it to reinforce some concepts, learnings at every step, and even to come up with proper questions to ask.

And did you feel comfortable about asking the questions during the game?

To others? Yes. You constantly get the feeling that you are making up the numbers while you are asking others questions. So I suppose learning a new board game as a novice, you have to give three four games just to get up to speed with the rules so that you can be competitive.

And in the first game were the objectives of the game clear to you before we started about what you had to do in order to win?

Yes, the main objective of getting to a certain number of points was clear. The permutations and combinations to get you there was the discovery.

Please describe your AR game learning session, which was the second game. How did the system work for you in terms of your input on the board and getting the output on the display?

Very effective, given that you could very intuitively go through five different steps, go back to the home page, and go to those five steps as many times as you need to, to reinforce your learning without asking anyone. The experience was very intuitive, very straightforward and at times, that could be used even while you are in the middle of the game, just to make a
decision and to reinforce the optimal decision. So very easy to use, and more importantly very helpful.

And after the AR method for learning, were you confident about the objectives and your actions during the game?
In the second game, oh yes. Completely relied on the recommendations if the dice numbers went my way, just followed the recommendations to the dot.

And did you feel a sense of control? Or were you happy just to follow the instructions given to you by the AR system?
I felt a sense of control, because as you do follow a step recommended by the AR interface, you could see the logic behind it once you have taken the step. So your confidence grows by every turn.

According to you what can be added or subtracted from the information you received through the AR setup?
It is a very complex game and there are a lot of things to remember, but if there was any particular information that you wanted or you thought was not needed.
I think one of the effective part of this AR interface was to keep it simple and minimalist. So I would not try to over complicate the information provided. I suppose in a more advanced setup when you get to a certain points, maybe it can give you a couple of options around how you may close the game. So it may do some advanced thinking for you and say “oh well, if you upgrade this settlement or take your chance with a development card, then, that recommendation to close the game can help at a later stage.

So you could you please compare for me the AR method for learning the game with the non-AR method, which was asking people and referring to the manual if needed. What were the differences?
Well one is you have to ask someone and maybe there is the human element of not asking multiple times whereas when you interact with a software you just ask it as many times as you need. So it removes that barrier of constant reference. The other part is that you actually feel like an equal player because you are aided with software with whatever smarts is available, you feel as if you are making independent decisions and you are competitive rather than just making up numbers from the onset. And thirdly, it was a very non-intrusive way. So rather than disturbing the other player’s thought pattern while they are making their decisions and rolling the dice you could look at what you should be up to in your next round. So it actually aids the game-flow because you are not interrupting anyone.

So you think the AR system worked for you?
Oh yes you can easily get used to it and if the aim was to learn a new game as fast as possible and play it as optimally as possible, it hit the mark.

On that note, thank you very much for the game sessions, and this interview. Would you like to give any final comments?
Lot of potential, obviously this is a research subject so you are focused on delivering a concept but the potential of this concept for wider gameplay, the board game industry and beyond is immense.
**Part 2: Testing AR System with Users:**

Session with DK described in Chapter 7, all other sessions are presented here.

Evaluation AM

Method 2 - Game 1

The test subject AM (marked with the red arrow in the image) does not play board games regularly. She is not familiar with Settlers of Catan at all. Being new to board games in general, and never have played Settlers of Catan before, she makes an ideal test subject.

Before the game began, AM was given a very brief introduction to the game metaphor: the map representing an island full of different resources, and each player representing a settler’s community. She was introduced to the game components: the tokens for building and cards for spending. This introduction to the game was very short and brief. Next, she was instructed on how to use the AR system. This included only the basics of interaction: how to trigger the different AR overlays on the map and how to interact.

Then, AM was left alone to navigate through the AR tutorial for 10 minutes. Her interaction was observed. Initially she was not sure about the interaction, and triggered false commands, and I had to intervene to explain the fact that AR buttons worked on occlusion, and can be triggered by accidental movements. After this, AM’s interaction with the AR overlays was smooth.
After 10 minutes of her interaction with Settlers of Catan Quick-StartAR, the game began. It was a three player game with AM, Player C, and me. Both Player C and I were old players familiar with the game, AM was the new player empowered by information through the AR system. She was free to refer to Settlers of Catan-Quick-StartAR whenever she wanted to during the game.

A brief but detailed game events chronicle follows. I was the first player, and chose a suitable spot for my first settlement, followed by Player C. It was AM’s turn. She chose the first spot as 6-9-3 stone-brick-wood. I asked AM to think aloud in the game to gain insights into her thinking process. She reasoned that she knew 6 and 9 were good numbers with good resources from the overlay 1. This presented her two node options: 6-9-3 or 6-9-2, and she knew the first was better because it has a higher node value. She was informed about node values in overlay 2. Thus, AM demonstrated that she retained information she received from the Catan Quick-StartAR. Next, she had to choose her second settlement, she was looking for a wheat-sheep overlap. (Thinking aloud,) AM mentions that there are no spots on the map where they overlap, therefore she should go for one at the cost of the other - the only way out. She reasons, wheat is more important than sheep. This information was displayed on overlay 1, and she proceeds to pick up a good wheat number and no sheep. This is the correct decision.

As the game moves on, and AM is looking to expand, she has no difficulty in remembering the 2-node rule, from overlay 2. In the ethnographic observations [cite], this is a minor concept but new players do struggle to grasp the rule. AM is looking for expansion and has two options: 6-2 stone-sheep, and 4-9-11 brick-brick-wood. AM makes a road towards the first option. She reasons, stone is more important, and she does not have sheep. Even though the probability of 2 rolling is quite low, she will go for that settlement first. She already has wood and brick, and the second option was not
adding a lot of value to the resource palette, so this can be considered as a reasonably-well thought out decision. In the following few turns, AM gathers more resources and then goes for her next option of 4-9-11 brick-brick-wood, she mentions, “on the first expansion settlement I was going for quality, now I will go for quantity.”

Now with a good supply of wood and brick, AM quickly builds the longest road and reaches 7 points first among all the players. This was the point till which it was decided the game would go on, and the game was terminated. It was also observed that AM traded quite well in the game (overlay 4) with other players and the bank. Her correct decisions for the first two settlement placement and the subsequent expansion settlements (overlays 2 and 5) ensured a good foundation. The other players did not have to play below their normal strategic level, and for them the challenge remained high, despite playing with a player who had never played Catan before.

Game 2

In this game, AM gets no help from either of the two players or the AR system. AM starts the next game by the roll of dice. Takes first settlement on 5-6-10 wheat-stone-wood. Correct choice. I’m next, and the map is pretty bad. Brief analysis: all brick together, all sheep together, very hard to make a strategy. I take 8-10-11 wood-sheep-sheep with a sheep port nearby. Player C takes 5-9-10 sheep-brick-sheep and 3-5-8 brick-wheat-wood. Excellent placements because of the number range and covers all resources. I take 3-4-6 brick-brick-wheat. So I cover all resources, with numbers with slightly less probability than Player C. AM goes for 9-11 brick-sheep. This is also a correct choice. AM goes for resource variety. Sheep is on a weak number – 11 – but she should get by without it. Many 7s are rolled, slow start as no one is getting any resources. Chini builds at 4-5 brick-wheat. My turn, I trade with AM, build on 4-8 stone-wood. AM rolls 7, blocks me on 8 wood – where I’ve got two settlements! AM builds on 6-9-12 stone-wheat-stone. Excellent move. Now she gets 2 stone on every 6. I suspect she is going for an early-upgrade strategy. Player C builds on 2-4-9 wood-brick-brick. Player C is on 4 points now! I lost wood on two rolls of 8 because of the robber. Player C builds a road and is one road away from longest road, AM points this out. She is more competitive than last game. AM has lots of cards in her turn and is trading quite well. She wants stone but no one has stone (to give). She is going for an upgrade. Player C takes the longest road, and is on 6 points now. AM upgrades. Interestingly, between 5-6-10 wheat-stone-wood and 6-9-12 stone-wheat-stone she chooses the latter. I ask her why, she explains that that settlement will get her more stone, although the other stone is on 12, it’s still more useful than the other option: wood. Arguably, the correct choice, but more importantly, complex reasoning. In the next turn, AM upgrades the second settlement! She is on 5 points now, player C on 6 and I’m still on 3. I build a settlement on 3-4-11 sheep-stone-sheep. AM builds on her turn! On 3-6 sheep-stone. AM is on 6 points now. AM refuses to trade with player C. I think she realises that trading will reduce her chances of winning. AM rolls a robber, blocks player C. With a roll of 6 and 9, AM has plenty of stone and wheat. On her turn she upgrades and wins the game with three upgrades and one settlement to make it to 7.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
For his first settlement, W goes for 2-4-9 wheat-wood-brick, with a node value of 8. And later, in his second turn for placing settlements, W goes for 5-8-10 sheep-brick-stone, with a node value of 12. Between the two settlements, W has node values of 20, which is a strong position to build on in the game. W covers all five resources, but the problems with his starting positions is the weak wheat production on 2, a number that is not likely to roll very often. W doubles on brick - on 8 and 9, both good numbers, and W also doubles on wood - on 3 and 4, both reasonably good numbers. It can be assumed at this stage that W is focusing on getting more wood and brick for making more roads. This strategy will allow W to expand easily, as well as go for the Longest-road 2 points.

As the game progresses, W starts off by building a road, then another road, but interestingly, he decides not to go in the direction he first intended to. Instead of moving inland, he decides to move towards the coast, and get one of the two ports within building distance. This is a correct decision, as posts will allow him better trades and reduce his dependency on other players for the slow production of Wheat, the only limitation in his strategy. Next, he upgrades his settlement, and correctly chooses the stone settlement to upgrade, as it will produce more stone, which will allow a faster upgrade for the next settlement. Next, W builds two settlements on ports. This places him in a very strong position, and soon after, W builds the longest road and claims victory. In this game, we see a very strong strategy in play. The first two settlements are placed in good spots, and expansion steps are taken correctly. Understanding of the concept of the ports and trading can be directly linked to receiving the information from Catan-QuickStartAR. The game was played for 46 minutes.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
D2
For his first settlement, D2 goes for 3-5-8 for wood-sheep-brick with a node value of 11. For his second settlement, D2 goes for 3-4-6 for wood-wood-wheat, with a node value of 10. Between the two settlements, D2 has a node value of 21 - a very strong start. The shortcomings of the initial placements are repeating resource - wood - on three numbers. D2 does not produce one resource stone, but overall, all other 4 resources are on numbers with good probabilities.
As the game progresses, D2 starts off by building a road and a settlement. This is a sheep port, and as D2 produces sheep on a reasonably good number - 5 - this is a good choice. Next, D2 places his second settlement on another port, which will allow 3:1 trades with the bank. This is also a good move, as the higher node values are ensuring a steady flow of resources for D2, and the lack of production of Stone, at this point is not an issue. In the next few moves, sure enough, D2 trades the excess bricks he is producing for stone and upgrades a settlement. The upgrade is also placed on the correct spot. In the meanwhile D2 has claimed the longest road and wins the game with 7 points.
In this textbook game, D2 displays understanding of various concepts from Catan-QuickStartAR, right from the choices of the first two settlements, to the expansion actions, all moves are executed in a timely manner. There is no decision that is changed as the game has progressed, D2 displays a good control over the game. The game session lasted 23 minutes only.

 Criteria | 1st settlement | 2nd settlement | Basic Strategy | Expansion | Speed |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
For her first settlement, P goes for 5-6-10 for sheep-wood-stone with a node value of 12. This is the best spot on the map, and this decision was correctly made by understanding the node value concept introduced in overlay 2 of Catan-QuickStartAR. For the second settlement, P goes for 3-6-12 for wheat-wood-sheep, with a node value of 8. Thus, the combined node value of both her settlements is 20 - reflecting good choices made for resource production. However, initial analysis reveals that P does not produce brick, and has wheat on an average number - 3.

As the game progresses, P builds her first road, correctly choosing a node that will produce brick. In the next few turns, P is able to build a settlement on brick at 8, and henceforth produces brick quite regularly. Next, P upgrades a settlement, correctly choosing the stone settlement which will help her produce more stones for speedy upgrades of other settlements.

Owing to the weak wheat production center, P is not able to expand faster than other players, and has reached 4 points with an opponent claims victory.

In this game, P displays some understanding of concepts of node values, but not of complimentary nodes for resource variety. It should be noted, that of the options available to P for her second settlement, it was impossible for her to cover all five resources. The game lasted for 27 minutes.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
For her first settlement, K goes for 6-9-12 for wood-brick-sheep with a node value of 10. At her turn, the best spots on the map were not available to K as they had been taken by opponents. This can be considered to be a good choice because despite of the very weak number 12 for producing sheep, 6 and 9 are both very good numbers for production of wood and brick respectively. For her second settlement, K goes for 3-11-12 for wheat-stone-sheep with a node value of only 5. This is an extremely bad choice. There are two possible explanations for this. Frist, K does cover all five resources, and it appears that this resource variety strategy has been given more importance than information about the node values. Thus K is not able to compare the concepts and choose a better one. Second, K makes a common new-player mistake (as was confirmed in later discussion) by assuming that both the starting settlements must be close to one another. Although there were plenty of hints in Catan-QuickStartAR that the settlements need not be placed so, K forgets this fact and ends up with a poor starting position with a combined node value of only 15.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
As the game progresses, K builds a road in the correct direction for expansion. K upgrades the correct settlement first, and is able to build roads towards the coast and in the next few moves is able to make one more settlement and upgrade. K is able to perform these actions despite of a below-average starting positions because of the remarkable rolls of the dice in her favour. This uncertainty is inherent in this scenario, and K benefits well from it, as she is able to build the longest road and claim victory. The game lasted for 35 minutes.
V
For his first settlement, V goes for 5-9-10 for stone-brick-sheep with a node value of 11. For his second settlement, picks 3-4-6 for wood-wood-wheat, with a node value of 10. This is an very strong starting position, as the combined node value of 21 ensures good production of resources, additionally, V has gone for resource variety strategy which means he covers all five resources as well. This is a fantastic place to start the game from.

As the game progresses, V builds a road, and is able to quickly upgrade his settlement. He makes the correct choice for the upgrade - he chooses the settlement with stone and higher node value. The road is placed on a good spot for expansion as well as V appears to be going for a node value of 8, and double up brick and wood. In the next moves, V builds another settlement, and takes the longest road, winning the game with a short margin as his opponent (yellow) was also had the same amount of roads and needed only one road more to win. But V is able to keep the road and build another settlement to claim victory. The game lasted for 27 minutes.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
For his first settlement, Dh goes for 3-8 wood-brick on the coast. This is not a good choice, as the node value is only 7. It can be assumed that Dh is going for wood and brick to build roads and this is the only spot available on the map that has both the resources overlap, but does not remember the concepts of node values, nor resource variety. For his second settlement, Dh goes for 2-5-9 wheat-stone-wheat with a node value of 9. This is an average spot and the combined node values of Dh’s settlements is only 16. Moreover, Dh does not have any nodes producing sheep, and wheat production is very weak on 2, and wood production is very weak on 3. It can be arguably assumed that despite the clear hints of Catan-QuickStartAR regarding node values and resource variety strategy, Dh does not take the suggestions in the hope of playing better than what has been suggested. This is a player trait observed in ethnographic studies as well, but as personality traits are out of the scope of this research, this observation is not relevant.

As the game progresses, Dh builds a road and a settlement. This is at a 3:1 port, but as not many resources are produced, going to the port is not a good choice. Dh upgrades a settlement, correctly choosing the settlement producing stone, but as his game is challenged by very low production of resources, Dh is on 4 points when an opponent claims victory.

In this game, Dh displays very little decision making informed by Catan-QuickStartAR. An interesting personality trait is observed, but it is not relevant to this research. The game lasts for 36 minutes.
R
For his first settlement, R goes for 6-9-10 wood-brick-stone. This node has a value of 12 - the best spot on the map. For his second settlement, R takes 3-11-12 wheat-stone-sheep. This is not a good choice as the node value is only 5. The combined node value of R's initial starting settlements is 17 - a below-average value. As has been observed in a previous game, the new player has gone for the resource variety strategy, as suggested by Catan-QuickStartAR, but has not understood the node values concept properly to apply to both settlements.
As the game progresses, R makes a road towards the stone port. This is not required at the moment, as a road towards an internal node would have yielded more benefits in terms of production. R upgrades a settlement, wrongly choosing the settlement that produces less stone and with a lesser node value. R's game does not advance much because of less resource production. R only manages to reach 3 points when victory is claimed by his opponent.
In this game, we observe R understanding the resource variety strategy from Catan-QuickStartAR, but not the concept of node values. The game lasts for 34 minutes.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For his first settlement, H goes for 6-9-10 wood-brick-stone with a node value of 12 - the best spot on the map. This clearly indicates that the information received by H from Catan-QuickStartAR helped him make this decision on the new map. For his second settlement, H goes for 3-6-11 wheat-wood-sheep, with a node value of 9, thus the combined node value for H's first two settlements is 21 - a very strong start. However, even as H displays understanding the resource variety strategy by going for the second settlement at a spot that covers all resources, his production of wheat and sheep is on weak numbers - 3 and 11 respectively - that won't roll very often, thus producing a limited amount of these resources.

As the game progresses, H builds two roads. One road is directed towards a stone port, and eventually he builds a settlement there, and the other is aimed to connect the settlements and go for the longest road. As the focus is on the longest road, H's game is limited in terms of upgrades and due to less production of wheat H is at 4 points when an opponent claims victory.

In this game we observe H understanding the node values concept and resource variety strategy, but not so much the need to upgrade settlements, and instead the focus is on getting the longest road. The game lasts 32 minutes.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
L

For his first settlement, L goes for 2-4-6 wheat-wood-wheat with a node value of 9. Wheat is on a weak number - 2, but as it doubles up on 6 it is not a problem. However, going for such a spot is not a good move. For his second settlement, L goes for 8-10 wood-sheep with a node value of 8. Thus a combined node value of 16 is quite low, and not a good position to start. Moreover, L does not cover stone or brick - a disastrous placement.

As the game progresses, L builds a road in a direction of brick and sheep, which is a good move, as L does not earn brick at all. L builds a settlement there, and builds two more roads, followed by another settlement, on a node with a value of 11. Interestingly, L is able to do all this building by good negotiation skills while trading. Initially, L starts with no brick production centres, and is still able to expand and progress reasonably.

In this game, L displays good improvisation and negotiation skills. After below-average starting position, he manages to progress reasonably. Good negotiation skills helps him overcome the limitations of not having brick in the early game. L closes his game on 4 points, with attempting to go for the longest road, an opponent is able to claim victory. The game lasts 34 minutes.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
AJ
For his first settlement, AJ goes for 3-5-8 wood-sheep-brick with a node value of 11. For his second settlement, AJ goes for 3-11-12 with a node value of only 5, thus starting the game with a combined node value of 16, quite below-average. AJ does however cover all 5 resources, as suggested by Catan-QuickStartAR and places the first settlement as per the suggestion of the AR system, but is unable to link the node values concept to the placement of his second settlement.

As the game progresses, AJ builds a road and a settlement on a sheep port. This is a good move, as he is unable to expand on the other settlement because of building of opponents' settlement. A sheep port would also help as AJ earns sheep on 5 - a good number, and sheep is worth less in trading with other players as well. Interestingly, AJ is able to improvise during the game and keeps his game ticking, and ends up with claiming the longest road. It is not possible for his opponents to go for the longest road for their own reasons, and thus AJ is able to keep it, and as he upgrades one of his settlements and build a settlement at a 3:1 port, he is able to claim victory.

In this game, although AJ places the second settlement on an average spot, all his other moves are according to suggestions from Catan-QuickStartAR, for instance, placing the first settlement, going for resource variety, going for ports. The game lasted 37 minutes.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1st settlement</th>
<th>2nd settlement</th>
<th>Basic Strategy</th>
<th>Expansion</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Part 3: Testing AR System with Experienced Users:

Catan-QuickStartAR is presented to three experienced players, and the documentation of their interaction and comments is presented here.
In these tests, I demonstrate Catan-QuickStartAR to experienced players and document their response about the usefulness of the system. I conducted the sessions with three experienced players who are familiar with the game and who also engage in board games as a recreational activity. Including these players in the tests for validating the system is essential. The system is designed explicitly for the new players at their first board game session, and the goals of making the task of learning the game easier for new players by providing contextual information when in action can also be seen as being aimed to take the load of experienced players, who do not have to worry about explaining the game concepts to new players or play a game in which they are not too aggressive to win - they can get on playing their normal game, as if playing with other experienced players.

Procedure
Experienced players are brought to the physical setup where Catan-QuickStartAR is deployed and I explain how to interact with the AR system. I paint the overall picture with broad strokes: the number of layers, the buttons that trigger these layers and how to switch between them. I also have to explain the technical constraints like the layer-switching time and the possibility of false triggers when using the occlusion-based 'virtual buttons'. I leave them to interact with the system and when they are finished I have a discussion with them with a semi-structured interview format. I urge them to ask questions intermittently and think-aloud as they interact. Here I present the observations made while these players interacted with Catan-QuickStartAR and the highlights of the subsequent discussion.

Experienced Player 1:
NT interaction with Catan-QuickStartAR
NT interacts with the first layer: resources. He places the poker-chip on the different tiles before figuring out what the information means. He inquires about the captions “Importance: High” that are displayed for each tile. He tries to move on to the nodes layer, but then remembers that he needs to go to the main menu first, using the back button before he can do that. On the nodes layer he reads the text aloud and continues this practice for the rest of his interaction. On the final layer, he is excited about the dynamic overlay that displays a corresponding node when the user choses a first node.

Discussion
NT describes the system as being particularly useful in the following aspects:
the association of the game card image with the production tile on the map, which is described in layer 1. The node values that are displayed in layer 2, which is helpful not only for displaying the node values, but also can explain the user how these node values are achieved. And finally, he mentions that the strategy layer is most useful because it provides basic information that will let new players form a basic strategy - the popular resource variety strategy and that will start the new players on a good foundation for the game.
NT describes the concerns with technical issues of the system, how “it takes a little getting used to” and that could play a factor in the performance of new players who are playing the game itself for the first time. The information is sufficient to help the new player start the game. For future enhancements NT suggests displaying information on how to close the game would be useful, for instance, if Catan-QuickStartAR can suggest “build two roads and a settlement here to win the game,
and watch out for [blue's] road here” it will help new players perform a chained actions to win, or is another player is able to win the system can explain how the player won.

Experienced Player 2: Interaction and Discussion
NG interacts with the system and asks lots of questions which turn into discussions, thus here I present observations on his interaction and discussion as one analysis. On the resources layer NG interacts with a few tiles and immediately wants to discuss the list of things that can be added to the information. He asks why more information is not added to the layer like the role of resources and commonly understood facts like “brick is more important in the first half of the game, and stone in the second half” and that brick and stone have less production centers, etc. On the nodes layer NG comments that giving the node values can be very useful, as in the past when he had explained the game to new players and mentioned how to calculate new values, the new players still had trouble calculating them prior to placing their settlements. On the production layer, NG thinks the system can give more information about each node, not just the three example nodes as is currently demonstrated. On the ports and trading layer, he mentions ports not being an important consideration for new players in their first game. And finally on the strategy layer, NG wishes to get more information on more strategies, not just the resource variety strategy. If the layer presents a few examples of the starting setups “it would be nice.” Overall, NG appeared to be more focused on enhancing the system by providing more information, and mentions that more information may not be suitable in this scenario where you expect the player to be playing and learning, but suggests a use of Catan-QuickStartAR only for learning the game, without playing it.

Experienced Player 3:
KK interacts with the system and does not ask too many questions. He has some difficulty in navigating through the layers, as there are false positives on the occlusion-based triggers, but he relies on his own ability to figure it out. He spends a short time on the resources layer, moving on to nodes layer and then the earning layer. He pauses and appears to be thinking about the concepts presented thus far, and evaluating the progression, before moving on to the next layers.

Discussion:
KK mentions that the first layer is very useful as it helps new players associate the game resource cards with their production centers. He says that the nodes layer can be of great help to new players, and it should definitely help new players pick their first settlement correctly. He does not have a lot to say about the next two layers, earning and trading, expect they “do the job”, and is most interested in discussing the last layer: strategy. He thinks this layer is immensely useful as it provides information on getting a starting position on the map with a good yield of resources. He recalls his past experiences where he had to help new players place their first and second settlements and he mentions the risks there. “If you dont help them, they are likely to go for poor nodes, thus ruining their game as they wont be earning a lot of resources, and if you help them, they are over reliant on you for the next steps as well. The human factor is cut out by using Catan-QuickStartAR, and thus these risks do not come into play.” For the limitations and future enhancements, KK mentions his familiarity with AR as a technology and it is a good idea to split the camera and fixing it on the top of the table, however, he suggests deploying Catan-QuickStartAR on a wearable setup for instance, by using google glass.
Part 4: Observations and Notes during players’ interaction with Catan-QuickStartAR
W

“Oh okay there is a 3 in 1 port, and there is a 2 in one port. Starting to understand a little bit about ports.” Reading aloud the port.

C: do you wanna see the resources? Resources shown, C hints they are the same colour.

“Now I wanna go back, I can just do that can’t I?” uses hand instead of the poker chip.

I’m explaining settings layer. Why is thinking about placements in terms of 2 settlements gets a strategy. Okay so you want to accumulate a variety of resources. Thinking aloud about the action: places the pokerchip on a node and tries to remember the names of resources, and then tries to remember the names of other two resources on the highlighted options.

Gotcha. That makes life easier doesn’t it, to know where to go next? That is helpful.

So I guess to start with, knowing ... (pause) ... now which one was it? The one with the numbers, good overlay nodes? Nodes! This one. Hmm! Okay. Do we get started and I keep learning as we play along?

Yes, you need to know where you want to place your first settlement, and then the second one.

I’m still not a hundred percent sure about it all, but I guess I’ll learn as I go.

So my first settlement, I get two free ones right?

Ya, but, you only place one first, everyone does that in the first turn and then the everyone places the second one.

Okay, so what does it say: the best ones are there. Hmm. Suggesting to place on one of those isn’t it?

W places first settlement, and is told to put the road connected to the placement.

I take W to the last layer... so these are the options for the second settlement.

Now there is obviously going to be another player going for the same spot that I want.

Whats this one? Robber.

So it’s my turn now? W asks. No its not, it’s my turn again, for the second round it goes the other way.

I explain the technical features of the “buttons” and how multiple buttons can be pressed at the same time.

I tell W, I hope you had a good look at your second settlement because as we place pieces now, the systems fails because these pieces act as button-presses. I have W replies confidently, I know exactly where I am going. Do you have a plan B? If that spot is taken where are you going to go? (no answer)

I think aloud my actions, tell him how I can’t go for the other two resources (because no spots are available). #Experienced players have no problems doing that.
W worries about if his actions are “correct”. I wonder how many people have placed the settlements where I have placed them.

Roll the dice, begin the game.

9 rolls, explaining how production happens on 9 hexes, Will gets it, “like it says on the layer!”

W thinks about the city. Wiz of Oz tells early expansion hint. W goes against it, the ports and trading seems to have caught his imagination.

So is it more important to speed up and build more cities, or is it more important to try to speed up and build more settlements? Answer: Depends on the board, on what you are getting, and depends on your strategy, how the map is (the map is randomised), how other players are playing.

Roll of 7... Explaining the 7-feature in the game.

W is most worried about if his choices are “usual” and correct.

Trading and ports,

Game goes on, turn after turn.

W questions about the cards we are holding in hands, we had laid them out on the table before, I tell him it’s the first game so it doesn’t matter, but he insists on keeping them private 😊

Game goes on, rolling, earning, trading, building.

C wins.

--------------------------------------------------------------------------------------------------------------------------------------

W2

oh that’s a 3:1 port and so that’s a 2:1 ports
starting to understand a little bit
“this port trades two stones for any card”
recalls all resources names quickly and correctly.
Okay, wheat is food. Is that relevant? Not really.

Ok now i’ll go back, and i’ll do that.
Ok so what have we got here?

Me explaining how to start the game with two settlements, and good corresponding nodes, and explaining the last overlay.

Ok so you want as much variety of resources. Okay so this one is wheat, brick and sheep, its telling me build over here yet because stone and wood and brick. So brick doubles up. That makes life easier doesn’t it? To know where to go next.
So I guess to start with, knowing... Which one was it? The overlay nodes with good overlay nodes is where I want to start.

Still not 100% sure, but that’s all right, I’ll learn as I go.
So what did it say, the best one was, suggesting me to go.

What are the first resources I want? Food is important! Oh but that doesn’t matter. So I’ll start with one of the good node here and ... work my way around the map I guess. So need to go to the layer with red squares again to get hints for the second settlement.

Now there is obviously going to be some sort of advantage in trying to guess what spots other players are going for and stop them getting there.

So why is this happening? (I explain how occlusion-based triggers work, the limitation of the system)

Okay so I’ve had a good look at the second settlement, I know exactly where I’m going. What if I take that spot? Do you have a plan B? W is thinking.

What’s all these big squares? These big red squares? (I explain again how occlusion-based triggers work)

Ok here’s my second settlement. I’m relying on your system now.

– Starting game –

So I have four varieties. There are four resources that I’ll be getting not five.

D2

Me explaining the game, the metaphor. It’s all about resource management. This explaining the system’s role.

So what do I do here? (On overlay 1) I explain. Okay so suppose I put it here. Reads aloud. Going through a few tiles. Oh, again brick? Wood again? Oh, so there are more than one spots for each resource. How is the importance different? It doesn’t make any sense! The numbers are different. (I explain the dice) I can’t remember all this! I’ll check this later, can’t I?

Me explaining the occlusion-based triggers, how you need to take your hand off.

On overlay 2. Reading aloud the “this is the node where you build a village” what does it mean some nodes are better than the others? I explain the dots on the numbers on the map. Oh! Okay! Now I get it! So this is best node? Yes that’s correct.

Overlay 3. Production. Oh so I can point at these blinking nodes. Reads aloud. Okay I understand that. That is easy.
Overlay 4. Reads aloud “you can trade 4 cards of a type for a card of your choice.” so what are these blinking buttons? “You can press them” okay, got that. So you have written over here. 2 : 1 - only sheep? Only sheep here. There is one port each.

Overlay 5. Explaining strategy. Oh so any one of these. Got that.

P

Oh but there I wanted the second settlement he's taken it! So I need to remember the options that I had for this second settlement. What was the reason for those options? (i explain cover all five resources) oh! I get it now.

Does the second settlement have to be near the first? No the options were all over the map.

So what are the resources I have? Correctly recalls the resource names. So I have (these three) and I need (this and this and this) and so (this) repeats. Does that matter? You will earn more. Okay, so need good numbers as well as all resources.

How does the road help? Explaining expansion. So I can go here or I can turn here also right?

So I got this because a nine rolled and I have this village on sheep.
So 6 and I don’t get anything, but both of you get brick. actively engaging in the game.

So I want to build a house and I cannot build here because it is too close to this one.

Throughout the game, “thinking aloud” for other player actions. High level of engagement, especially in trading.

I have so many sheep. I can trade them for brick. Although I cannot build a road now, i can keep the brick for later, yes?

—– P interacting —-

Ok so on every roll of 10. Everyone gets resources?

So can i start with a home on a port? isn’t it better, then you can trade better? No, but you get only 2 numbers. Oh yes, ok.

Next game me-chini-preeti

Oh 9, i’m earning a lot of grains.

Long negotiations during trading. Trading cards for no immediate actions, planning ahead for next steps.

So how many points do I have right now? (Counting points for all players.)
i earned a stone here. Stone! Now I can upgrade. Which is better to upgrade? This one because these are good numbers.

“Now if a 6 is rolled then I get a wheat and then I can trade for a stone and get an upgrade.”

– Game 3 C-D-P –

This is grain, this is wood, if I put it here, I will have too much wood. I want stone and I have to come all the way here. But it is on 5, which is not a great number. I'll get wood and brick, I'll put here.

Oh this is a meaningless settlement. I'll go for the port next.

--------------------------------------------------------------------------------------------------------------------------------------

L

Strategy layer. Resource variety strategy. Why shouldn't I go for overlapping resources to double the production? Because you will need all resources in the game. So it's a good idea to diversity.

The goal is to reach 7 points. All reach 7? No just one winner. What is a point? i explain the settlement 1 point and upgrade 2 points. And the longest road 2 points.

Explaining occlusion-based triggers, how the system breaks down.

--------------------------------------------------------------------------------------------------------------------------------------

K

Me explaining role of Catan-QuickStartAR.

Oh, why did that happen? I explain how occlusion-based triggers work.

Nodes. Oh node have values? How did you get them? I explain. Oh I see. Oh, so these big squares are better because you add these dots and get the probability. Yes. I get it.

Earning resources. Reading aloud. So both these nodes produce sheep, but one has to be better because the last layer had different node values for each node. So it’s all probability isn’t it.

Ports. Reading aloud. Oh, Okays. Remembers all resources names correctly.

Strategy layer: understands the strategy layer quickly after being informed about the rationale (resource variety strategy).

--------------------------------------------------------------------------------------------------------------------------------------

V

Explaining the game. Explaining how QuickStartAR works.

V starts interacting. I have to quickly explain about occlusion-based triggers.
Resources. So basically “food” resources are more important than other stuff, is that right? And when you get the resources, in the form of these cards I assume, where do you spend them?

Nodes. How are these values occurring? I explain the dots. So the first settlement I can place anywhere? On one of these higher number nodes, I see.

Production. Reads aloud. So anyone can roll this number and I can earn a resource? Good question!
Strategy. I explain the rationale, the variety dynamic.

Can a person object a trade? I explain that is not allowed in the game. He explains why it should be, to stop players gangng up against a player and taking him or her out of the game, I explain the 7-block dynamic to address his concern. An insightful concern raised by a non-gamer at his first game, and when the answer was explained to him he was even more engaged.

V thinking loud while choosing first settlement, makes informed decisions. Displaying better understanding of game actions by often doing more things on his turn, like trading and building, trading and storing for future, building two things, etc. Negotiating more in trading and pushing his agenda more.

– Q&A –

Take me through your game.
My strategy was to keep a good distance between settlements to allow for future expansion for both settlements, which I achieved here and here. The app helped me in placing the first settlement, and when you changed the geography of the island, I knew the node value numbers. The ports helped making a strategy, I looked at the resources I could trade at ports, and then looked for the 6s and 8s on the map for those resources.

You went more brick and stone, what were you thinking. The first strategy was to get more brick and build the longest road. That would allow me to expand easily into stone producing areas. So I was going for both. What was the first strategy between the two you were going for? The first was the longest road - get brick strategy. That is potentially easier. Upgrading is difficult because you have to get 3 stones.

Why didn’t you go for the ports in this game? The numbers, I believe, were not that good near the ports, and I realized you need good numbers to earn. You might get away by not going to the ports.

How comfortable you would say you are with the game? Very comfortable, I could play another one. I don’t play board games but now I want to play this one.

--------------------------------------------------------------------------------------------------------------------------------------

H

Resources. So why are there 8 eights? One is over here and one more is over here. So most important is repeated? But I see there is no seven! I explain the 7-robber dynamic.
How do you decide who is winning? I'll see later.

What are the letters for? I explain the numbers need to be arranged.

How do you win and lose in the game? I'll explain later.

Nodes. Minimum distance is 2. What two? A: two of these sides. Oh so these numbers are the node probabilities. Why are 11 and 12 highlighted? I believe they have very low probability. No no, thats a node value, not node probability. So how do you calculate node values? Add the dots. I give a couple of examples. Oh, so the game already tells you the number of dots. And the layer will tell you the node values, so I don't have to calculate the node values.

--------------------------------------------------------------------------------------------------------------------------------------

AJ

But wouldn't you just go for a node with the highest value? Yes. But wouldn't two people want the same node? How do you resolve that? I explain how it's decided who goes first in the initial settlements phase.

And what's this? The robber. I explain the robber. So the robber blocks production. How can you remove this the robber if it's on your spot?

Production. No questions.

Appendix V

Software Code

This appendix contains the code that enables the 5th overlay in the AR system software prototype design iteration 5. The rest of the code is not documented in the exegesis because of the length of the code. I present the code here to illustrate the backend of the AR system.
using UnityEngine;
using System.Collections.Generic;

public class ComboEventHandler : MonoBehaviour, IVirtualButtonEventHandler
{
    private GameObject c1, c2, c3, c4, c5, c6, c7, c8, c9, c10, c11, c12, c13, c14, c15, c16, c17, c18, c19, c20, c21, c22, c23, c24;

    void Start()
    {
        // Register with the virtual buttons TrackableBehaviour
        VirtualButtonBehaviour[] adam = GetComponentsInChildren<VirtualButtonBehaviour>();
        for (int i = 0; i < adam.Length; ++i)
        {
            adam[i].RegisterEventHandler(this);
        }

        c24 = transform.FindChild("Cube1").gameObject;
        c23 = transform.FindChild("Cube2").gameObject;
        c22 = transform.FindChild("Cube3").gameObject;
        c21 = transform.FindChild("Cube4").gameObject;
        c20 = transform.FindChild("Cube5").gameObject;
        c19 = transform.FindChild("Cube6").gameObject;
        c18 = transform.FindChild("Cube7").gameObject;
        c17 = transform.FindChild("Cube8").gameObject;
        c16 = transform.FindChild("Cube9").gameObject;
        c15 = transform.FindChild("Cube10").gameObject;
        c14 = transform.FindChild("Cube11").gameObject;
        c13 = transform.FindChild("Cube12").gameObject;
        c12 = transform.FindChild("Cube13").gameObject;
        c11 = transform.FindChild("Cube14").gameObject;
        c10 = transform.FindChild("Cube15").gameObject;
        c9 = transform.FindChild("Cube16").gameObject;
        c8 = transform.FindChild("Cube17").gameObject;
        c7 = transform.FindChild("Cube18").gameObject;
        c6 = transform.FindChild("Cube19").gameObject;
        c5 = transform.FindChild("Cube20").gameObject;
        c4 = transform.FindChild("Cube21").gameObject;
        c3 = transform.FindChild("Cube22").gameObject;
        c2 = transform.FindChild("Cube23").gameObject;
        c1 = transform.FindChild("Cube24").gameObject;
    }

    public void OnButtonPressed(VirtualButtonBehaviour eve)
    {
        switch (eve.VirtualButtonName)
        {
            case "n1":
                c5.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                c12.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                c16.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                break;
            case "n2":
                c4.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                c5.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                c9.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                c10.transform.localScale += new Vector3(0.045F, 0.045F, 0.045F);
                break;
        }
    }
}
case "n24":
    hexring.transform.localScale+= new Vector3(0.4F, 0.4F, 0.4F);
c4.transform.localScale+= new Vector3(0.045F, 0.045F, 0.045F);
c5.transform.localScale+= new Vector3(0.045F, 0.045F, 0.045F);
c9.transform.localScale+= new Vector3(0.045F, 0.045F, 0.045F);
c10.transform.localScale+= new Vector3(0.045F, 0.045F, 0.045F);
break;

    case "back":
        Application.LoadLevel("Scene0");
break;

    }
}

public void OnButtonReleased (VirtualButtonBehaviour eve)
{
    switch (eve.VirtualButtonName) {
        case "n1":
            c5.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c12.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c16.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
break;

        case "n2":
            c4.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c5.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c9.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c10.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
break;

        ... ...
        ...
        ...
        ...
        ...
        ...
        ...
        ...
        ...

        case "n24":
            hexring.transform.localScale+= new Vector3(0.4F, 0.4F, 0.4F);
c4.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c5.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c9.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
c10.transform.localScale+= new Vector3(-0.045F, -0.045F, -0.045F);
break;
    }
}