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Serious Games: improving the Learning Effect with Hybrid Games

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Abstract

Previous work at NTNU has sparked an interest in hybrid board games. These kinds of games combine elements in digital and board games together. This has resulted in a platform called AnyBoard, which is a platform that makes it easier for developers to create and develop hybrid board games. The platform was created at NTNU and has been worked on by students and employees at the IDI institute.

This thesis aims to investigate this platform, and look at the potential it has to influence learning. In order to investigate this, games for learning were looked at and the learning principles they used were identified. Different hybrid games were also looked at to see how they were used and what possibilities they offer. After initial studies a prototype of a serious game was created. This was based on a previous card tool called Tiles Cards, and was turned into a game and made hybrid. The new version was tested and evaluated with users and found to be entertaining and provided the players with new knowledge.

Sammendrag

Tidligere arbeid ved NTNU har økt interessen for hybride brettspill. Dette er spill som kombinerer elementer fra digitale og brettbaserte spill sammen. Dette har resultert i en plattform som heter AnyBoard, som er en plattform som gjør det enklere for utviklere å lage og utvikle hybride brettspill. Plattformen ble opprettet på NTNU ved IDI instituttet og har blitt arbeidet på av studenter og ansatte.

Denne oppgaven har som mål å undersøke denne plattformen, og undersøke potensialet den har for å påvirke læring. For å finne ut av dette, ble andre spill undersøkt som hadde læring i sentrum, og læringsprinsippene de brukte ble identifisert. Hybride spill ble også sett nærmere på, for å finne ut av hva som fantes der ute. Etter innledende studier ble det opprettet en prototype av et seriøst spill. Dette var basert på et tidligere verktøy kalt Tiles Cards, som ble omgjort til et spill og gjort hybrid. Den nye versjonen ble testet og evaluert på brukere og funnet å være underholdende og ga spillerne ny kunnskap.

Preface

This project is a master's thesis at NTNU as part of the MSc programme in Computer Science and was carried out the autumn semester 2016 and spring semester 2017. The work has been supervised by Monica Divitini.

The work was motivated by my interest in IoT and games. The AnyBoard platform was an interesting project and presented me with some ideas when starting on the project.

I would like to thank my supervisor, my fellow students and special thanks to Hans Magnus Vethe Hallaråker who also worked on AnyBoard at the same time as me and helping me out a lot. I would also like to thank Simone Mora who is responsible for the development of AnyBoard.

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Abbreviations

IDI Department of Computer Science

IoT Internet of Things

ICT Information and Communication Technology

NTNU Norwegian University of Science and Technology

1 Introduction

Board games have long been a source to entertainment, interactivity, knowledge, strategic thinking and bonding among people. They have been played for thousands of years, and boards have been found that dates back to ancient times[1]. Ever since then, board games have stayed popular and are still being used frequently in modern days, by all groups of people for amusement and social aspects. New board games still pop up, and classics like Chess and Monopoly continues to stay highly relevant. Many board games are being released new versions of and modernized. Recent trends in board games also use ICT to combine the interactivity of computer games with the benefits of board games [1]. These digitalized board games; hereafter called hybrid board games are what this project will explore.

1.1 Motivation

According to [2] "Playing board games is an engaging social experience characterized by two levels of interaction: between the player themselves (e.g. discussing strategies) and mediated by physical artifacts". It is mentioned by [2] that traditional board games allow the players to sit around a table face-to-face and they can use gestural communication. The game pieces allow for tangible interaction and physical feedback. This is reasons for games being popular as a medium for learning. When mixed together with new technology the goal is that the affordances will come in addition to, and not be replaced by the technology. Technology should provide a richer, more engaging and interactive game experience without taking focus away from the purpose and what the game wants to learn the players in the game.

As stated in [2], with the development of desktop PC's arcade games, and game consoles, board games got the opportunity to be translated. The use of ICT provided a richer game experience with AI and NPC's, and games could be completely virtualized, removing the tangibles of board games. But this removes the face-to-face communication and the cooperation that is so vital to board games [2]. Also Keyboard and point – and click with the

[1] https://en.wikipedia.org/wiki/Board_game

mouse, or touching a smartscreen on a phone does not have the same affordances and close interaction as a board game, making it harder to get direct feedback and communicate.

Many games over the years have been known for teaching skills. A game like Scrabble teaches words, chess teaches strategy and planning, and Monopoly teaches the players about math and finances. These games reach wide audiences and are examples of popular traditional board games. Especially board games are popular among the elderly, offering a cross-generational form of entertainment [3]. There has recently also been made hybrid board games like Monopoly STARS and Futura described in [2], but how these games impart knowledge is a bit unclear.

In addition to being a good tool for learning, board games are easier to make than fully digitalized games. The creator does not have to be worried about creating complex graphics that is common to many video games. The costs are also noticeable lower as stated in [4]. This makes board games a good and cheap way of teaching skills through a game. How hybrid board games can be used for learning is lesser known and one of the objectives this thesis seek to research.

1.2 Objectives

A platform developed here at IDI is based on elements from digital and board games. It is called AnyBoard and has digitalized tokens and a game engine. This platform is intended being used in this thesis. The task will be to develop a hybrid game with learning objectives and evaluate the learning effect. A tool for learning about design and technology called Tiles are intended being used as an example game. This consists of different cards and have a good potential of being digitalized and renewed in a new version. The new version will be compared to the old one to see how they are perceived differently. This leads to the following research questions:

RQ 1: How can AnyBoard be used to influence learning?

RQ 2: What benefits do AnyBoard provide in terms of learning?

RQ 3: What serious games and games for learning are existing in hybrid formats?

The thesis will investigate how AnyBoard can be used in the domain of serious games and games for learning. To investigate this I will use an already existing card tool, and make a new version based upon the AnyBoard platform. Playtests will be run to evaluate if the users of the newly adapted game got the intended learning outcome of the game and the learning objectives of the game. The aim is to see how the digital, interacting game content added to the board game will impact the learning objectives. The planned outcomes of my thesis will be:

1. A game prototype of a tool for learning about technology, called Tiles Cards developed by the institute. The AnyBoard platform will be used to make the prototype.
2. An evaluation of how the platform can influence learning.
3. A look at existing hybrid board games and how they are used.

1.3 Limitations

The Anyboard platform will be used in its current version when starting on my thesis. Any limitations or problems with the platform could have an influence on the work, but is not part of this thesis to solve them. In my thesis, I will be developing a prototype by using the platform but my goal is not to develop the platform further.

Other projects in the same time span as my thesis will have the task of developing to the platform, and might expand it with new functions or add new technology to it. The platform might therefore have new features and opportunities at the conclusion of this thesis, that could have been useful for my work. These improvements will not be used though, since when designing for the platform I must consider what is in place at the time of the planning.

I will not evaluate the technical aspects of the platform. I will have the standpoint of a game developer and see how the platform best can be used in my project.

1.4 Approach

The first step in this thesis will first be to read up on the existing work done on the Anyboard platform. This will give an overview and see what potentials the platform offers. Further I will see what other hybrid games exist and if some of them focus on teaching skills. Searches on the internet have shown to have a few results of these types of games, but implementations on other platforms could provide some good knowledge on games intended for learning.

The second step will be to make a prototype of a game with the AnyBoard platform. This will take an experimental approach and design choices has to be made by me as a developer, with as much grounding in the literature as possible. The finished prototype requires playtesting with test subjects and surveys or interviews need to be done after to see if the learning goals and expected outcomes of the games was reached.

1.4.1 Design science

This thesis will lend principles from Design science, a research paradigm. Design science is increasingly used in the Information Systems (IS) field. The IS research framework is built around three design science research cycles shown in Figure 0.1**Error! Reference source not found.**. The relevance cycle, the rigor cycle and the design cycle[4].

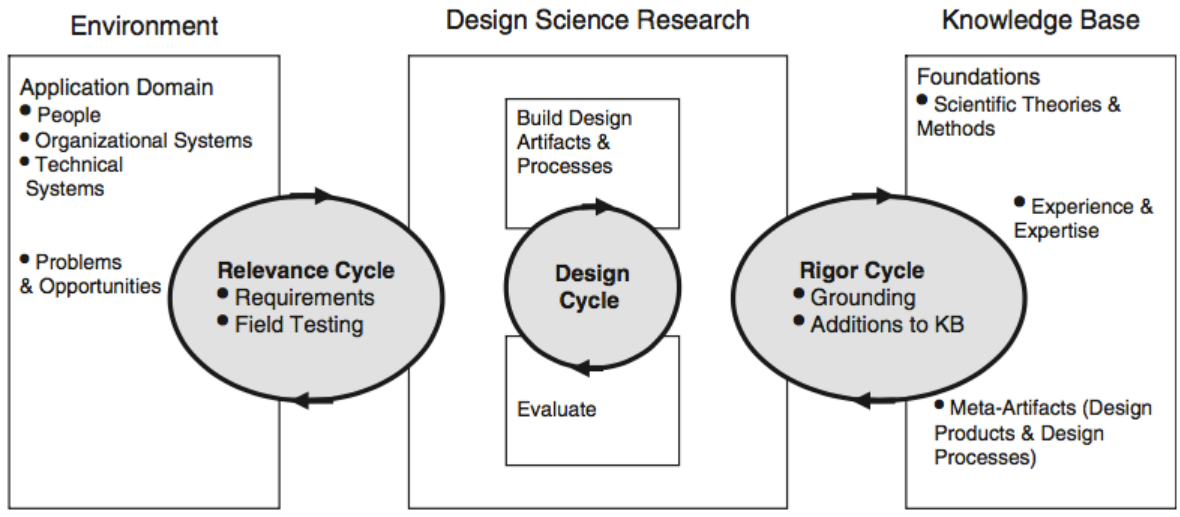

Figure 0.1. Design science research cycles. From [4]

In [4] it is laid out that design science research is motivated by the desire to improve the environment by the introduction of new and innovative artifacts. In the relevance cycle,

design science research is initiated with an application context that provides requirements for the research as inputs, and also determines how to evaluate the research results. [4] describes that this cycle should consider if the artifact improve the environment, and how this improvement can be measured. The output of the design science research should then be returned to the environment for evaluation or field testing.

In this thesis, the relevance cycle is used at the beginning of the project to find out about the AnyBoard platform, what it is used for and potential tasks and research problems that can be defined. Later some thoughts should be put into how the prototype of the game (the artifact) should be evaluated. This will be an output of the research brought back to the environment. In the end, look at how the research problems was addressed.

The rigor cycle provides past knowledge from the knowledge base to the research project, in order to ensure its innovation. A researcher should reference to the knowledge base to show that designs are new contributions[4]. The knowledge base consists of state of the art in the application domain and existing artifacts and processes found in the application domain. Design science research should be grounded from the knowledge base. Additions to the knowledge base include additions or extensions to original theories or methods, the new artifact and experiences from the iterative design cycles and field testing of the artifact. [4] claims that contributions to the knowledge base are essential to selling the research to an academic audience just as contributions to the environment are the key selling points to a practitioner audience.

In this thesis, there will be a review of the literature on different types of games for learning and platforms being used in order to understand the application context better. Also, the work on hybrid games and the AnyBoard platform will be looked at. This is an example of a work that will belong to the relevance cycle. Hopefully, new results will be added to the knowledge base at the conclusion of the design research.

The design cycle is the heart of the design science project. Where the construction, evaluation and refining of the design takes place. It takes requirements as input from the relevance cycle and evaluation theories and methods are drawn from the rigor cycle. According to [4] there should be a balance of constructing and evaluating the design artifact. The artifact should be tested along the relevance cycle and contributions to the knowledge base should be added via the relevance cycle. This cycle will be all about designing and evaluating the game in this thesis.

1.5 Structure of the report

The report is structured as follows:

The Introduction contains the description of the thesis with motivation and objectives. It also includes limitations and the approach taken.

In section 2, literature about serious games is reviewed with definitions and different types. This section also presents different principles used in games.

Section 3 describes relating work and games targeting the hybrid platform.

In section 4 the previous work made on hybrid games by the institute are elaborated. Also the game that I will base my prototype on is presented.

Section 5 describes the approach taken by me to implement the game with methods and reasoning behind the choices that were made. It also gives an overview of the game.

In section 6 the evaluation of the game with playtests and feedback from users is found.

The last section includes Summary and recommendations as well as future work that can be carried out.

After the references follows an appendix with a user manual for the game.

2 Theory

This section will describe games and serious games and look at some of the research done in this area. It starts by defining games and serious games and what makes them good learning tools. It also highlights what makes games motivating.

2.1 What is a game?

There are many definitions of the word game. They can be found in different areas of the gaming literature, and they exist for traditional (i.e. non-digital) and digital games, and for learning and entertainment purposes. A book by Whitton [5] highlights some definitions the author finds useful.

Ellington and colleagues define a traditional game as simply having two characteristics: rules and competition (which can be either among players or against the game system) [6]. But this definition might be too basic, and games based around puzzle-solving do not neatly fit into this definition. Another definition by Klabbers that is typical among educationalists working with traditional games is saying that a game is "an activity or sport involving skill, knowledge or chance in which you follow fixed rules and try to win against an opponent or solve a puzzle" [7].

The area of commercial games has definitions that are more focused on entertainment and user experience. Some game designers include intangible aspects such as fun and playability in their definitions. Oxland says that "computer games are defined by rules and boundaries, feedback, an interface to the game world, context and sensitivity, goals, quests and challenges, a game environment and playability" [8], while Koster provides a much less detailed definition, saying simply that "games are puzzles to solve, exercises for our brains" [9]. Because of the focus on entertainment, it is unsurprising that there is a greater focus on the user experience in the game designers' definitions described here.

Definitions can be found specifically to the field of digital game-based learning as well. These are the most interesting for this thesis. Dempsey and colleagues define a game as "an activity

involving one or more players, with goals, constraints, payoffs and consequences, which is rule-guided, artificial in some respects and has an element of competition", while Prensky (2001) describes six structural elements of games: rules, goals, outcomes and feedback, competition or challenge, interaction, and representation or story. A wider definition is used by de Freitas who defines computer-based learning as: "applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences"[10].

Lastly, Brathwaite put forth the following tentative definition: "An activity with rules. It is a form of play often but not always involving conflict, either with other players, with the game system itself or with randomness/fate/luck. Most games have goals, but not all (for example, The Sims and SimCity). Most games have defined start and end points, but not all (for example, World of Warcraft and Dungeons and Dragons). Most games involve decision making on the part of the players, but not all (for example, Candy Land and Chutes and Ladders)" [11].

By looking at these attempts to define games it is evident that there are many ways of viewing games, and the definitions are not matching but have many common characteristics. When making an educational game with the AnyBoard platform the definitions for digital game-based learning are most useful.

2.2 Educational and Serious games

Trying to close in on the game this thesis aim to realize, serious games are worth looking at. These games are mainly targeted for learning and education. The idea of using games for other purposes than fun was first formulated in the book Serious Games by Clark C. Abt published in 1970. He states "We are concerned with serious games in the sense of that these games have an explicit and carefully thought–out educational purpose and are not intended to be primarily for amusement"[12]. According to Breuer and Bente the educational purpose does not necessarily have to be in the game's design but can be assigned to the game by the context it is used or embedded in[13]. Further they claim that for example a board game originally designed for fun can be used in a military training context to teach strategy and principles of tactical warfare. While the learning process takes place via the game, the effect intended by it may well be an exogenous one.

A good and well-known example of a successful serious game was America's army. This was a game developed to see if it could be used for training in the military. A sergeant reported that when new recruits had trouble with the rifle range or the obstacle course, his team had those recruits play America's army and required them to complete those levels in the game, as seen in Figure 2.1 [14]. The game would also eventually end up as a good recruiting tool for the army.

Figure 2.1 America's army. Training simulator. From [14]

From the definition of serious games made by designers Michael and Chen in 2006, we can still see that Abt's definition from 1970 is valid. They state that "a serious games is a game in which education (in its various forms) is the primary goal, rather than entertainment"[15]. This definition requires a broad understanding of education as there exists serious games that don't have education as primary focus, but still counts as serious games. Another definition proposed by Zyda reads as follows: Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" [14]. Zyda continues with describing video games as story, art, and software, highlighting that what separates them with serious games is the addition of pedagogy. Pedagogy being activities that educate or instruct, thereby imparting knowledge or skill. The definitions by Zyda looks at any kind of change in a person after being exposed to something external like a game. Figure 2.2 shows what Zyda describes. Even though this counts in larger commercialized game projects with dedicated teams, it is also relevant for smaller projects like in this thesis. The figure illustrates the pedagogy element that is added for making games into serious games.

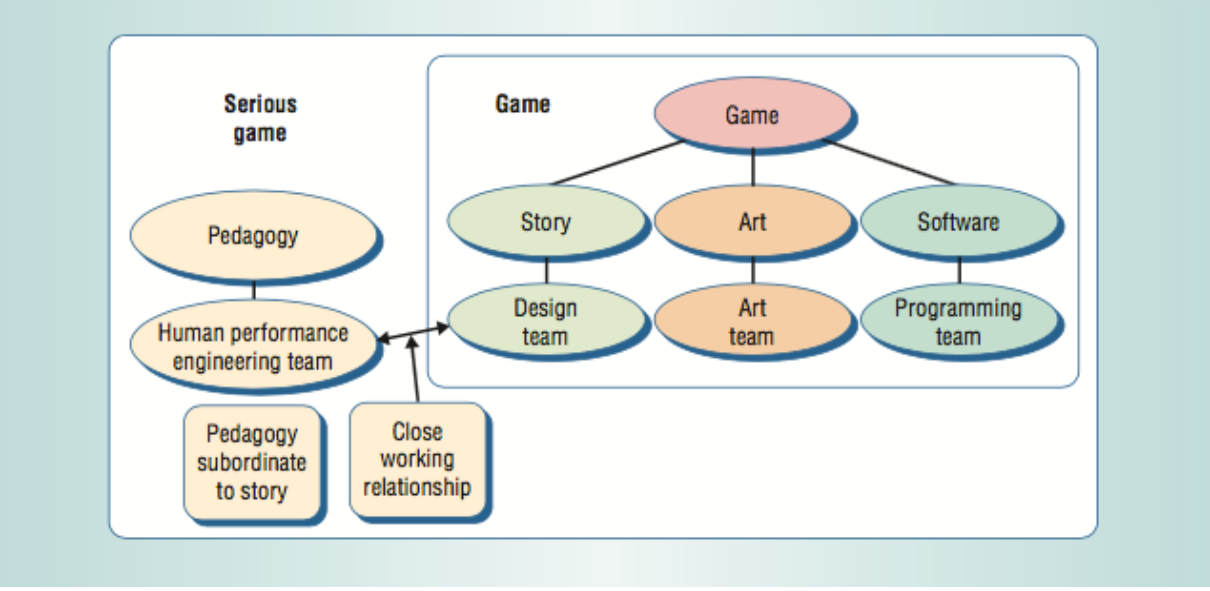

Figure 2.2 From game to serious game.

Unlike their entertainment-only counterparts, serious games use pedagogy to infuse instruction into the game play experience [14]

After reviewing the literature and looked at some of the definitions of serious games, it is certain that the game that will be realized in this thesis can be classified as a serious game.

What is clear to be common in the descriptions of serious games are that they are games used for more than just mere entertainment, just what this thesis is about.

A point to mention about serious games is that there are many types and a wide term. A serious game does not necessarily need to be about education and learning. Breute and Bente[13] mentions art, therapy and advertising as other application fields. Another label that could describe the game in this thesis is the game-based or digital game-based Prensky[16] uses in his book. These labels are partly overlapping serious games and the former is almost identical to Abt's pre-video game definition of serious games. The latter is identical to video games with/for education. Game-Based Learning is a subcategory of the wider term entertainment education and includes the use of any types of games (e.g. Board games, card games, sports or digital games)[16]. That means the game can be put under these labels as well.

2.3 Why are games entertaining when learning is hard?

According to Breuer and Bente [13], learning is usually a long, complex and difficult process. They continue by saying that while people enjoy challenging games, they dislike and avoid challenging learning experiences in school education or professional training. They find this interesting though, if one consider that playing a game is always associated with learning. Further they state that just like games, learning is an interactive process, challenges the learners, and has more or less explicit rules on how to acquire new knowledge or skills[13].

This brings the question what makes games so entertaining? Breuer and Bente [13] mentions the specific mode of interactivity they offer. This form of human- computer interaction can happen on different levels:

1. On a micro-level of individual inputs and outputs (e.g. you push a button and your character moves)

2. On a narrative level (i.e. you interact with game elements such as non-player characters to progress through the game and unfold its story)

3. On a meta-level of setting and manipulating the game's rules (this includes choosing a difficulty levels as well as cheating or creating your own game content via editors)

These chances for interaction provides the player a feeling of self-efficacy. The player will feel their actions is effective in the game world and this motivates further interaction and gives a sense of control. The interactions is also important for the experience of flow [17], a term researched by Csikszentmihalyi who conducted extensive research into what makes experience enjoyable, based on long interviews, questionnaires, and other data collected over a dozen years from several thousand respondents. The adaptability of the game is crucial to enable the flow state, since players are differently experienced. How much resources the player are willing to invest in the game is depending on this playing experience [16, 18]. To keep the players playing games have to be "pleasantly frustrating" [19], i.e they need to be challenging without being unmanageable.

A short and more simple explanation of what makes games entertaining is their ability to create engagement. According to Gee[20], games that are engaging hover around the borders of a players competencies. As mentioned in the last paragraph they should be “pleasantly frustrating”. Games should also avoid boring content, in fact boredom is found to be worse than a game being too challenging. Baker et al. found that boredom in computer learning environments is shown to be associated with poorer learning and problem behavior [21]. They also found that frustration was less associated with poorer learning. This means that a game produced should have a good balance to engage the players. A good definition of engagement by Benyon and colleagues[22]:

“Engagement is concerned with all the qualities of an experience that really pull people in – whether this is a sense of immersion that one feels when reading a good book, or a challenge one feels when playing a good game, or the fascinating unfolding of a radio drama.”

Flow theory comes into play here. Flow is essential to being engaged. Being in a flow relates to be in an optimal state. It is described as “the state in which people, are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it”[17].

Whitton [5] has found elements from flow theory that add to enjoyment and they are listed under. The more of these elements are present, the more enjoyable, engaging and immersive an activity is:

- a challenge that requires skills with an attainable goal and known rules;
- complete absorption in the activity;
- clear goals;

- immediate feedback;
- concentration on the task in hand;
- a sense of control, lacking the sense of worry about losing control;
- loss of self-consciousness;
- transformation of time.

A second theory that is important for engagement is worked out by Malone [23]. A way to keep players engaged is to use the principles made by him. Tom Malone's theory of intrinsically motivating instruction lists three categories to make things fun to learn: Challenge (goals with uncertain outcomes), Fantasy (narrative and imaginary content), and Curiosity (sensor curiosity through graphics and sound, and cognitive curiosity where the player should solve something unsolved). [23]

2.4 Blending learning and entertainment

Rieber [18] introduces challenge, curiosity, fantasy and control as criteria for an intrinsically motivating learning environment and state that they are largely similar to those in an intrinsically motivating game. From this it becomes clear that a game can be a great tool for learning since they share so many properties. When making a game the designer should strive to find the optimal balance between entertainment and learning for motivating players. This ideal mixture has often been called the "sweet spot" of blending games and learning scenarios[24]. Ritterfeld and Weber identify three approaches for combining entertainment and learning[25]:

1. Reinforcement paradigm: The entertaining parts of the game are offered as rewards for successful learning
2. Motivation paradigm: Entertaining game elements are used to evoke the learner's interest, focus her/his attention and make her/him ready for the learning procedure
3. Blending paradigm: The learning procedure itself is designed to be entertaining, i.e. the enjoyment of mastery in the game is equivalent to the enjoyment of the acquisition and use of knowledge and skills

The motivation paradigm uses entertainment as an extrinsic factor while the two others has intrinsic motivation. What paradigm should be chosen depends on the material and the assumed effect of entertainment in learning. Breuer and Bente[13] mean that the ideal educational game combines entertainment and learning in a way that the players/learners do not experience the learning part as something external to the game, thus suggesting the best motivation is the intrinsic.

A consideration when designing games for learning is the amount of entertainment. The addition of entertainment assists learning, but can also get too high, reducing the learning outcome. The entertainment part can overshadow the learning objectives of the game and remove the focus from them. Also, the difference between commercial entertainment games and games specifically designed for learning clearly suggests a trade-off between entertainment and learning. Rodriguez [26] tips when designing games to identify the playful elements of learning and to make games for educational purposes accordingly. This leads to the conclusion that elements of entertainment should not be put uncritical into a game.

2.5 Types of serious games

There are many classifications of serious games. Michael and Chen [15] name military, government, educational, corporate, healthcare, political, religious and art games. Subgroups of these also exists. Ratan and Ritterfeld [27] classified serious games in four dimensions in their analysis of existing games:

1. Primary educational content
2. Primary learning principle
3. Target age group
4. Platform

In the educational content dimension the games with academic content accounted for 63 %. Other games had social change, occupation, military and health as content to name some. The age group had four levels: preschool and below, elementary school, middle and high school, and college, adult and senior. Most games were targeted at elemental, middle and high school children (39%). Among the learning principle they found these concepts: practicing skills, knowledge gain through exploration, cognitive problem solving, or social problem solving. Practicing skills was most used as the primary learning principle (48%). The analysis revealed that 90% of the games were developed for PC, but games for a many different platforms were found.

From this analysis, it is clear there is a range of serious games used in different settings and on different platforms. The games have a variety of subjects and topics like history, politics, health, awareness and math. The serious game genre has many possibilities.

The work of Ratan and Ritterfeld laid the groundwork for an expanded labelling system that was helpful when designing a serious game. This is used in section 5.4 of this report to classify the game that was made in this thesis.

3 Related games and work

Interesting games on related platforms to AnyBoard is mentioned in this section. Searches on the internet did not locate any literature documenting learning effects from the use of dedicated hybrid board games. Therefore, some projects in the hybrid domain that were not targeting learning as their primary objective is mentioned. Games on other platforms is also mentioned here where the learning effect was studied.

3.1 Digital game based learning

One work which confirms that the use of digital games has a positive effect on learning through a practical example is the research conducted by Papastergiou. In a study where the effect of using a computer game for learning computer memory concepts was assessed, students using the game learned more and were more motivated compared to students using a similar but non-game teaching approach [28].

A study by Ebner and Holzinger [29] describe how they used an online game for teaching about structural concrete at a master's level. They reported that the minimum learning result of playing the game was equal to that achieved with traditional methods. An additional positive effect was that the fun factor was higher than expected. Game Based Learning made the players enjoy the game while learning. The content of the game and the implementation of a high score list should be motivating factors.

3.2 Study among senior citizens with augmented tabletop

A study performed by Paul Marshall among senior citizens tried to find out how the gaming experience was changed from a board game environment to a digital tabletop game [30]. A familiar game to the users that was participants in the study was digitalized and tested (see Figure 3.1) and several aspects regarding the gameplay were assessed. The study in [30] relates to this thesis since it involves digitalizing a traditional board game . It explored the augmenting of an already existing game, and the game were collaborative and social. Among

the results of this study the participants rated the tabletop version of the game, with multimedia, feedback sound, music and movement, to be more immersive than the analogue version, where immersive can be defined as the extent of involvement in the game. Involvement makes a good case for better learning. The game also was reported to be more dynamic, with more flow and an easier gameplay. This suggests that more of the time the participants spent on the overall objective of the game instead of worrying about the rules and what to do next. Another interesting point about the digital game was that social interaction was stimulated, meaning that digitalizing the game did not remove this aspect. The study also mentions that similar results have been attained in the context of game playing with children.

Figure 3.1 Seniors playing the game. From [30]

3.3 Jigsaw puzzle

Another interesting research was done by Jürgen Bohn who made a hybrid tabletop prototype game that augmented the physical pieces of a jigsaw puzzle with RFID tags [31]. The game can be seen in Figure 3.2. It was made for children and included game play variations of the classic puzzle game. It still looks like and functions like a classic puzzle game with original pieces, but with added functionality. A PC application demonstrates a virtual representation of the jigsaw puzzle's physical state. The application can automatically recognize added pieces and update the status of the game on the computer screen. The game can be played with points systems and time constraints for variation and competitiveness in the game.

Figure 3.2 The smart jigsaw puzzle with RFID equipment. From [31].

3.4 Other games found

In the end of this section about related games, a couple of commercial games that are made for entertainment is presented, but also learns the player something. One is a modernized Monopoly that uses credit cards and a terminal instead of hard cash[1]. This is a hybrid version, and it teaches finance and trading to the players. The terminal keeps track of the amount of money the players have. This shows an innovative way of adding digital content to a classic board game.

Another example worth mentioning is a version of the well- known game Cluedo which comes with a DVD[2]. This game uses a TV to present clues to the players instead of using the cards that is in the original. The players are provided with a whole new experience, and this shows of how a hybrid game can be implemented.

[1] https://www.hasbro.com/en-my/product/monopoly-electronic-banking-game:EB2C42C9-5056-9047-F52D-5E3CC0532D6B

[2] https://en.wikipedia.org/wiki/Cluedo_DVD_Game

4 Previous work on hybrid board games

As presented earlier in section 1, this thesis builds on some of the previous work on hybrid board games done by the IDI institute and three master students [32-34]. In this section I will describe what this work has consisted of, what results have been accomplished, and what is missing or recommended of future work from those who previously worked on it. I will elaborate on the AnyBoard platform, which is a vital result of the research done by the department, and has been used in the prototyping of hybrid board games. This section will also explain some common game mechanics and principals that are important when making games with the platform.

4.1 Don't panic

The first research made by the institute on hybrid board games resulted in a hybrid version of a game called Don't panic for training emergency workers, which can be read more about in [2]. This research brought some positive results regarding the game experience for the users. Among this, the use of interactive tokens in the game was reported by [2] to have good usability, to "add more interaction with people" and was letting "rules be clearer", with " no need to remember them" [rules]. In comparison to a traditional board game experience the play testers considered the game to be "amusing and more interesting".

What the research did not provide an answer for, was if the changing of the game experience had any influence on the training of the personnel, or if they had any increased learning outcome by playing with interactive pieces. This is what my research mainly will consider. One could argue that by letting a computer handle game logic and rules, the focus of the players could shift more to what the game is all about and what it intends to learn the players. But this was not the focus for this research and therefore provides no such evidence.

Concerns

Though the hybrid approach of the Don't panic game was successful in regard to gameplay and engagement among the players, it revealed some unresolved challenges that the

AnyBoard platform sought to improve and find solutions for. The biggest concerns according to [2] was:

- Complexity of the setup.
- The building of tokens. Both the Hardware part and communication among them.
- High costs.
- Reusability of the project for other games.

All these pointers helped providing requirements to the Anyboard platform that was created.

4.2 The AnyBoard platform

The AnyBoard platform provides interactivity to the traditional board game genre. It provides design entities to model interaction, interactive game pieces and the software library AnyboardJS.

4.2.1 Design entities

The design entities in AnyBoard and how they are mapped to traditional board game elements can be seen in **Error! Reference source not found.**.

Table 4.1. Mapping between AnyBoard and game concepts. From [1]

AnyBoard design entities	**Traditional Board Game elements**
Tokens	Game pieces
Constraints	Board tiles and sockets
Interaction events	Player actions

Tokens are technology augmented objects that replaces traditional game pieces. A token can simulate different kind of behaviors. A token can for example simulate the roll of a dice, the action of drawing card, detect placement on a board or detect when it's tapped or moved.

Constraints are either visual or physical confining regions on the board. Examples can be fields in Ludo or a checkers in chess. The placement of a token within a constraint can trigger certain game dynamics.

The interaction events are ways the players can interact with the tokens. There are three types of events:

- Token event – an action performed on a single token, for example shake, tilt or tap. The event can trigger a simulation of forexample drawing a card or rolling a dice in the game.

- Token-constraint event – moving a token to or from a constrained region on the board. Constrained regions in this case are colored sections on the board that the color sensor of the tokens can recognize.
- Token–token event – triggers when tokens interact with each other for example by moving a token next to another token.

4.2.2 Game pieces

The tokens can be seen in Figure 4.1, these are also called Anypawns on the platform. **Error! Reference source not found.**AnyBoard also has a printer for printing cards on the fly (aDeck on the figure). The Anypawns offer several sensors for detecting movement, colors and different constraints. The Anypawn can simulate different kind of behaviors. It can for example simulate the roll of a dice, detect placement on a board or detect when it's tapped or moved. It is also equipped with a LED that can display different numbers or letters. The printer can act as an interactive version of a deck that prints out cards for the players. The cards can then be printed with barcodes that can be scanned with the help of a smartphone for increasing the digital contents in the game.

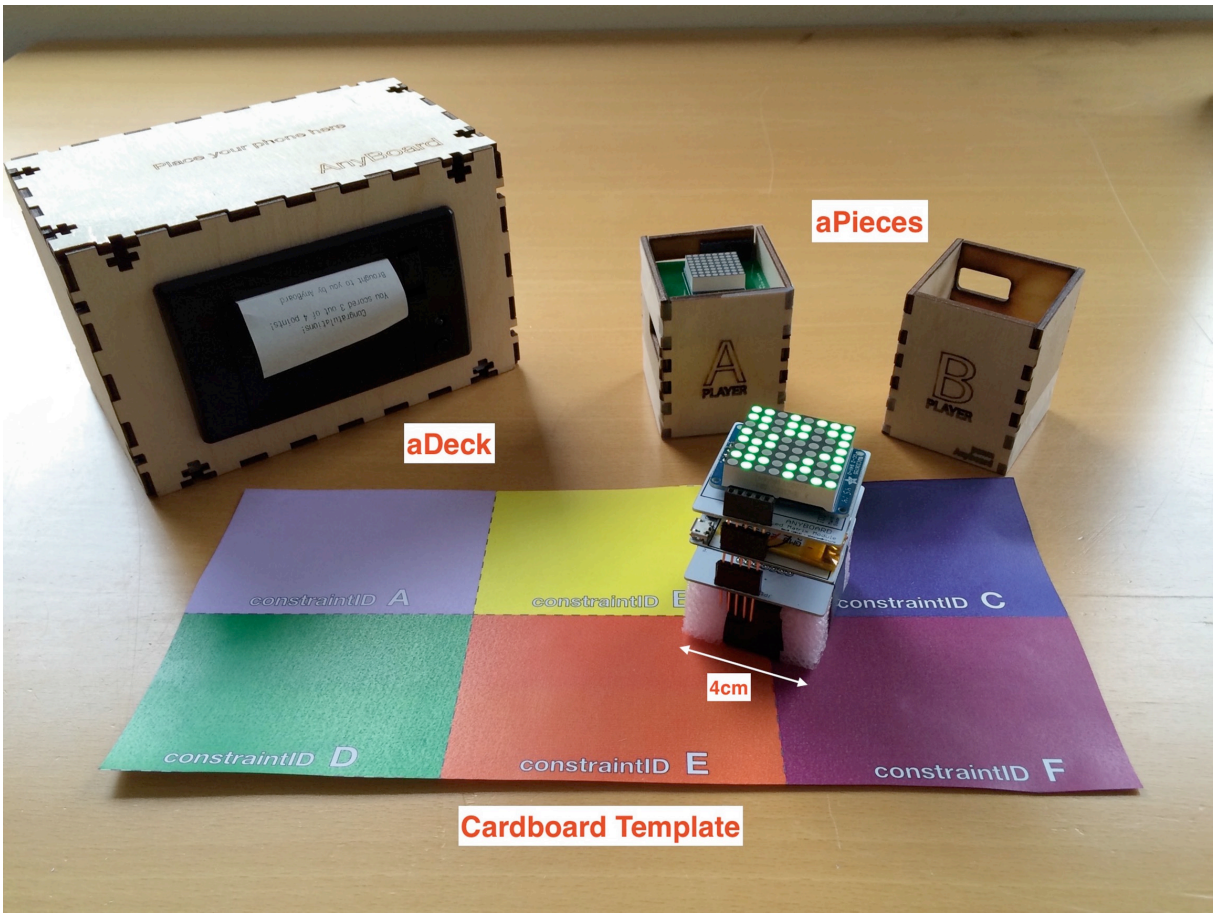

Figure 4.1 AnyBoard interactive tokens. AnyPawn, the printer and a cardboard template

The intention of the platform is to ease the development of hybrid board games and address the concerns mentioned in 2.1.1. According to [1] it is designed with the game developer

mind, to save them from taking care of low-level implementation detail like Hardware, firmware and low-level programming language. Communication protocols between the tokens are also ready to use. This way the barrier for starting to develop hybrid board games should be reduced, and more time can be spent on the game design.

4.2.3 AnyBoardjs

AnyBoardjs is the software library that is developed for AnyBoard. The code runs on a smartphone which needs Bluetooth to interact with the tokens. The library takes care of the communication with the hardware so the developer can focus on the events generated by the tokens and the game logic. It helps connecting to the tokens using Bluetooth. The library also offers some helpful classes and functions for simple board game elements like decks and dices.

The Anyboardjs library only requires the developer to have knowledge of web programming, mainly JavaScript. A game developer only needs to use the API provided by the library and write functions that responds to different events triggered by tokens. An article made about AnyBoard by the institute [35] highlights the unique part with Anyboardjs, in regards to the handling of token interaction when developing. This is performed by the Token Manager library seen in Figure 4.2. The figure shows the digital domain of the platform that provides device- specific drivers for tokens, and can be extended with the use of different game engines. [35]

As help in the beginning, AnyBoardjs comes with example code on a repository on github1. The platform also comes with an example of a game, the quiz game that uses colored board constraints and was been worked on by students in [32, 34] and improved upon in [33]This game can provide inspiration to developers intending to use the platform and is also a concrete example of how the platform works in action. .

[1] https://github.com/simonem/Anyboard

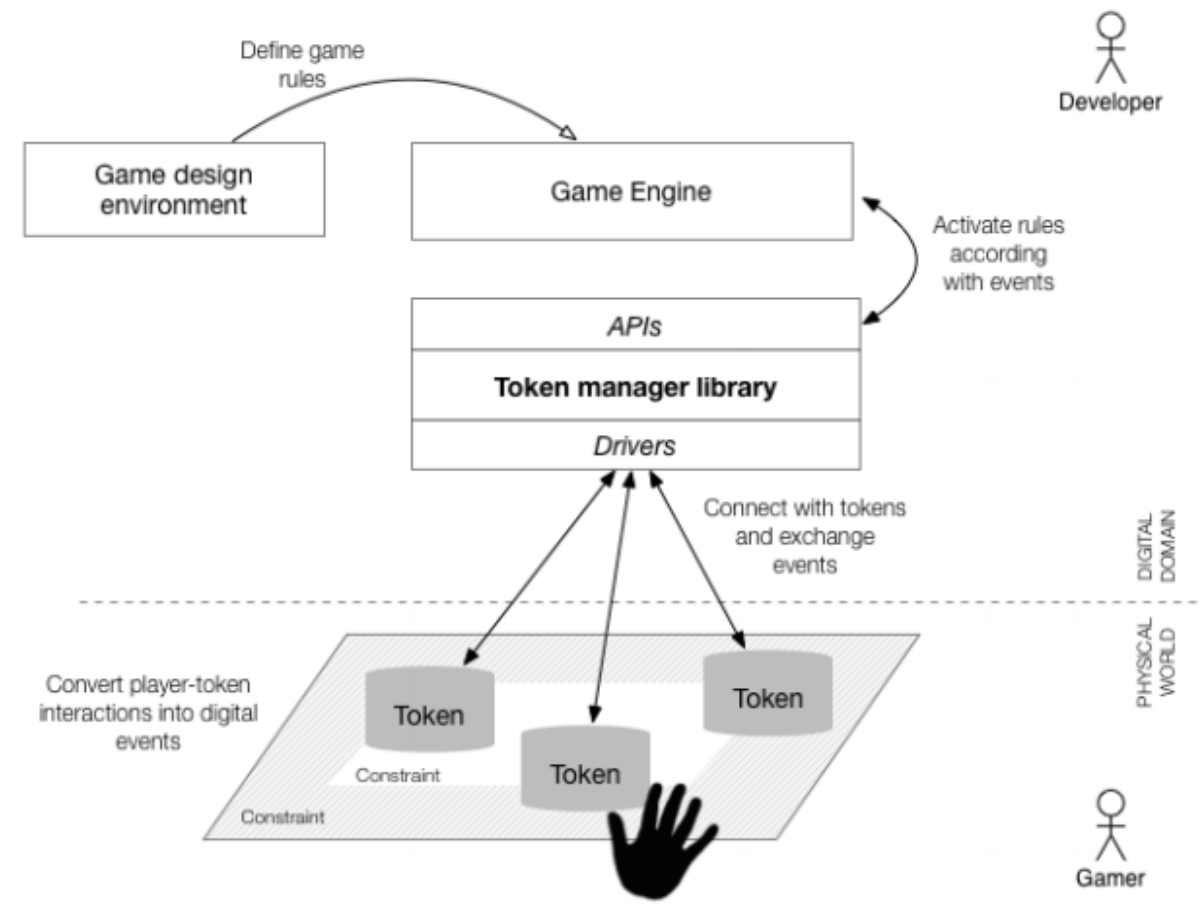

Figure 4.2 Components of AnyBoard from [35]

4.2.4 Summary AnyBoard

The AnyBoard platform have successfully been designed and tested and proved to be useful in the intended ways. How well it was for game development was attempted answered by Emil Schroeder in [33]. He concluded that the platform did support the game implementation process, but that some game actions did not map manually, often adjustments had to be made because of limitations on the platform. He speculated that digitalization of an already existing analogue board game would result in a "clunky" interaction design. He mentions that it would be interesting to see how a game not developed with the AnyBoard platform in mind would perform. That will be tested in this thesis when making the prototype of the game presented in the next section.

4.3 Tiles Cards

As written in the introduction this thesis will make a hybrid version of Tiles Cards. This is a tool created here on the institute. The goal is to "foster end-user design thinking of smart object applications" [36]. The theme is "Internet of Things" [1] (IoT) and it investigates how to make everyday objects "smarter" by embedding them with digital technology. Examples of smart objects that [36] mentions are: "a paintbrush that samples colors from surfaces and use them as drawing palette in a computer program, a water faucet that lights up in colors to display daily water consumption data and wood bricks that can be composed by children to create computer programs. According to [36] "technology can be used either to augment an existing purpose of an object, making it more useful, playful or engaging than the ordinary self or to add new functions that are controlled using the object's affordances.

IoT is a relatively new and complex field that can be hard to grasp and start working on because it requires competence in many areas. Hardware, Software, industrial design, creativity and innovation are all factors that come into place when working with IoT technology. You need an understanding of the traditional objects that you are working with and the technology that can be combined with the object to create something new and innovative. To simplify the process of working with smart objects, and to get end-user more involved, the work from the institute in [36] resulted in the Tiles Cards.

As [36] describes the Tiles Cards abstract the complexity of IoT technology into a set of interaction primitives and composition rules accessible by non-experts. It is played in teams and they are given the task of designing under some constraints. The cards are means to make the designing more engaging and playful, and they help facilitate conversation between stakeholders and designers. Cards are also a source for inspiration and it helps to have something concrete in hand when discussing ideas with other in the teams. It is important when redesigning the game to consider all these benefits, and the possibility of keeping the cards in the new game, since they could prove vital to the overall experience when playing. Replacing the cards with another representation, for example images on a screen could be more distracting for the players.

[1] https://en.wikipedia.org/wiki/Internet_of_things

The article also mentions that studies show that game rules add constraints that can improve design outcomes and foster creativity. For example, turn-taking helps ensuring that everyone is involved in the process. The new game could implement turn-taking but that would steer it away from an open discussion. Maybe the most important property of cards is that they act as "physical props to externalize thoughts and help structuring common grounds that everybody can relate to" [7].

4.3.1 Cards

The first version of the cards was seven decks divided in two groups. Primitive and game cards. According to [7], the primitive cards explains concepts proper of tangible interaction, while the game cards brings dynamics, rules and goals to the game.

The cards are two sided, the back of the card describes the category of the card while the front provides informative text and a an illustration as seen in Figure 4.3. Each category has its own color for easy sorting. There exists more than one of single cards to play multiple rounds without reshuffling. Each category also has blank cards the players can customize with own primitives and game rules. The intention behind this was according to [7] to promote creativity and out-of-the-box-thinking. The design of the cards was stated by [7] to be made for end-users to engage and contribute with their ideas in a meaningful way, without a lot of knowledge in IoT.

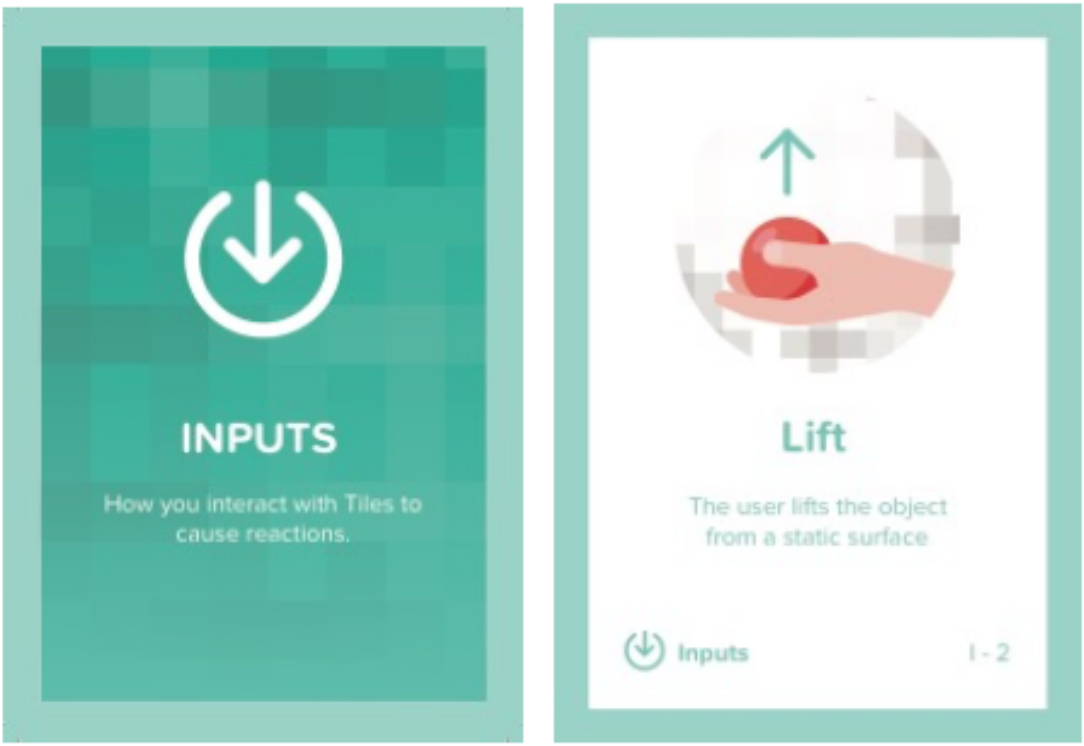

Figure 4.3 Front and back side of a primitive card.

From [36]

The Primitive cards are divided in four categories: objects, input, output and compound actions. Objects are items like a lamp, sink, jacket, and other things that can be made "smarter". Input describes gestural inputs on the interface of smart objects like touch, shake, rotate. Output from the object can be sound, light, vibration or color. [36] mentions that these primitives can be quickly implemented using technology toolkits such as Arduino and Little Bits. The last category is compound actions and describes special interaction among two or more smart objects. The primitive cards can be combined to make the interface of a smart object.

The game cards consist of three categories that add game mechanics to the Tiles Cards. The categories are Missions, Criteria and bonuses. Mission cards are goals the players should try to accomplish when combining primitive cards. Examples are missions with "coded information: create a concept that displays information that is useful to the owner, but not understood by anyone else" and "habit changing". Criteria cards provide guidelines to rate the outcomes of the mission. It could be in terms of enjoyment, creativity, user friendly and more.

Finally the bonus cards are there to change the game experience and change the rules during the game.

4.3.2 Improvements

The Tiles Cards was iteratively refined and the content changed after feedback from focus groups and evaluations of the tools with IT-students. The cards has been changed and the gameplay and ruleset has also been experimented with to better support the IoT domain.

The most recent version of Tiles Cards has been tested and evaluated in seven idea generation workshops with a total of nineteen participants [37]. In the recent version, the primitive cards are now grouped in 5 categories: things, human actions, feedbacks, connectors, and data channels. Idea generation technique was developed that make use of the cards together with traditional design activities such as sketching and storyboarding. A cardboard and a playbook was created to support those types of activities. The playbook adds constraints, rules and clarification to the gameplay without the need of supervising. The cardboard guides the users during the game and the overall process of idea generation by dividing into steps and showing ways to combine cards and help with sketching and add more visuals. The cardboard used can be seen in Figure 4.4.

Figure 4.4. Cardboard and playbook used in workshops.
Taken from [37]

The design workshops with the students revealed that the game was both useful and engaging. Most of the users agreed that the process and the use of the cardboard was partially "easy to understand and that the design process provided guidance to develop ideas" [37]. Most users also thought the information on the cards was useful and the design was appealing. But there were some things that the users noted that could be improved upon:

What the students appeared to be complaining most about or be confused upon was the connection between the board, the playbook and the cards. The need for a clearer playbook and better visual constraints was mentioned by some testers. Areas on the board was sometimes overlooked and not picked up by the students. Some reported the playbook was not well enough connected with the board and didn't identify where to place the cards on the board. Time constraints on each step of the game were not set strict but suggested by the playbook in this version of Tiles. The participants tended sometimes to get stuck on some steps and use too much time before moving on to the next step of the design process.

It was mentioned in [37] that addition of more elements and mechanics borrowed from traditional board and card games as well as computer interactivity could improve fun and user engagement aspects.

5 My methods

This section will describe the approach taken in this thesis for making the new version of Tiles using AnyBoard. As stated in section 1.2 a hybrid version of the Tiles Cards based on the AnyBoard platform would be produced. The goal was to answer if the AnyBoard platform can influence learning and how it differs from traditional board games.

What is important for answering this question is to test the game and evaluate with the players. This will be carried out by post-play interviews.

5.1 Initial process

Since the Tiles Cards in its original form is more a tool than a game, the new version has to contain elements from the game world. According to [11] game design is the process of creating content and rules to the game. Further it states that good game design is the process of creating goals that a player feels motivated to reach and rules that a player must follow as he makes meaningful decisions in pursuit of those goals. When making the game the creator takes the players standpoint and try to make the gameplay motivate the player by answering questions like:

- What´s this game about?
- How do I play?
- How do I win?
- Why do I want to play?
- What things do I need to do?

Game design in its essence is about creating opportunities for the player to make meaningful decisions that affect the outcome of the game.

5.2 Turning it into a game

As mentioned earlier, game elements should be added to the new Tiles version. Whitton describes in [5] 10 key characteristics that make activities game-like. These are characteristics that builds on literature about games. These characteristics are used in Table 5.1 to describe the game elements of Tiles. The more characteristics the new Tiles version possesses, the more can it be considered a game.

Table 5.1 Game characteristics

Characteristics	**In the game**
Competition	The design team aims for producing the best ideas. Also, getting the most points possible in a run.
Challenge	Some constraints in the game like time and cards available that limits the players.
Exploration	Many concepts and technologies to explore to find best solutions.
Fantasy	-
Goals	Complete the design process that results in a proposition of a smart object.
Interaction	The game logic will interact with the player. Instructions will be given on the phone for each step the players should go through.
Outcomes	The game will show the progress the players make and a points system will rate the idea the team end up with.
People	The people in the team play simultaneously and collaborate with each other.
Rules	The players are guided by the rules and constraints in the game. E.g. they have to complete one phase before moving to the next.
Safety	Ideas can be exchanged in a safe environment.

As can be seen in the table, the game will not include the characteristics of fantasy. The players will get the task of creating a scenario for their design and this could be looked at as

fantasy. But there is no narrative and all the concepts and technologies on the cards are very much real so the amount of made up content is very low in this game. Therefore, fantasy is excluded. Whitton also says that fantasy has perhaps the least obvious application to learning within higher education.

Safety is a characteristic that may require explanation. Whitton describes it as “the idea that games are consequence-free environments that can be experimented in and that the outcomes of the game have no penalties or rewards in real life”[5]. The ideas generated by playing this game could be carried out further and be realized. But in other cases, the game will not have consequences for the players.

5.3 Learning objective

A key challenge when designing a game, is according to Whitton [5], ensuring that the goals within the game support the learning objectives. If a game is designed in such a way that the progress necessitates engagement with the intended learning objectives, then it is much more likely to be a successive learning tool. When the game is designed, it should be ensured that it's motivating and engaging to the players, and also teach them what is intended. In [5] it is also argued that the mapping of learning activities into gaming activities fundamentally determines whether a game will be an effective learning tool or not.

The mapping can be seen in Table 5.2 below. The learning activities should be mapped to specific activities in the game. The activities are based on the learning objecties and they will be identified from the previous version of Tiles Cards from the documentation available. To identify the learning objectives is essential when evaluating if the game supports the intended goals or not.

Table 5.2 Mapping of learning objectives into game activities

Learning objective	**Learning activities**	**Game activities**
Learn about smart objects, and various technologies of the "Internet of things" (IoT).	Explore objects and concepts related to the IoT.	The players can look through different objects, internet services and interface metaphors, to learn about the possibilities IoT provide.
Learn about the designing of smart objects	Discuss and exchange ideas with others in a design team through different phases.	The players collaboratively go through different phases in the design process that is reflected in the game. The players are guided through the phases by the game. They discuss, exchange ideas and agree upon solutions.

5.4 Game labels

Breuer and Bente [13] proposes a labelling system that could be used for game designers of specifically designed serious games. This is being used in Table 5.3 to give an overall description of the new Tiles:

Table 5.3 Game labels

Label category	Label
1. Platform	AnyBoard (Hybrid board game)
2. Subject matter	Internet of Things
3. Learning Goals	Designing smart objects, Learning design process.
4. Learning principles	Exploration, collaboration, discussion
5. Target audience	Students, designers, developers, stakeholders or anyone with an interest for IoT.
6. Interaction mode(s)	Multiplayer
7. Application areas	Academic use, workshops
8. Controls /interfaces	Smartphone, Anypawn, board, cards,
9. Common gaming label	Interactive card game

The learning goals are taken from the previous section. The learning principles are some of the principles that was suggested by the labelling system and could be used. The remainder of the labels should be self–explainable.

5.5 Game design with AnyBoard

The phases for a full development of an AnyBoard game is according to [35] :

- Game design, i.e. the definition of game concept, logic and rules
- Interaction game design, i.e. the definition of the interactions
- Mapping of the game into the associated token + constraint system.
- Implementation of the HW and SW, this might range from implementation of game engine to the development of token interactions.

The article also states that if students are given the task of implementing a serious game where players are expected to learn X, the implementation part might be less relevant and the main focus should be on the first phase of game design. When making the game a great effort was put into the game design. What was done in each phase of the development of the new Tiles is elaborated in the following sections.

5.5.1 Game design

In the beginning of the game design I was putting ideas out there. The ideas below seemed the most proper ones.

- The game will start with overall instructions on the mobile screen. The approximately time to finish it, the way to navigate and other basic instructions to get started.
- The focus of the game will be in the early stages of Tiles Cards. They involve the stages of idea generation and designing of the smart object. These stages should be most suitable to transform with the use of AnyBoard.
- The goal of the game will be to come up with an idea to a smart object. I will make a points or resource system to the game, to make it more challenging and enjoyable. This will add a secondary goal to the game. This will also add an element of competition in the game, to try to get as much points as possible. I propose three ideas:

1. This smart object will get points for creativity. The cards will have points on them or another point system will be used based on the amount of cards used, the complexity or so. See Figure 5.1.
2. The players can only use a certain amount of cards. The cost for each card is displayed on them.
3. The players will get awarded for creating designs at a fast phase. Getting more points for fast decisions.

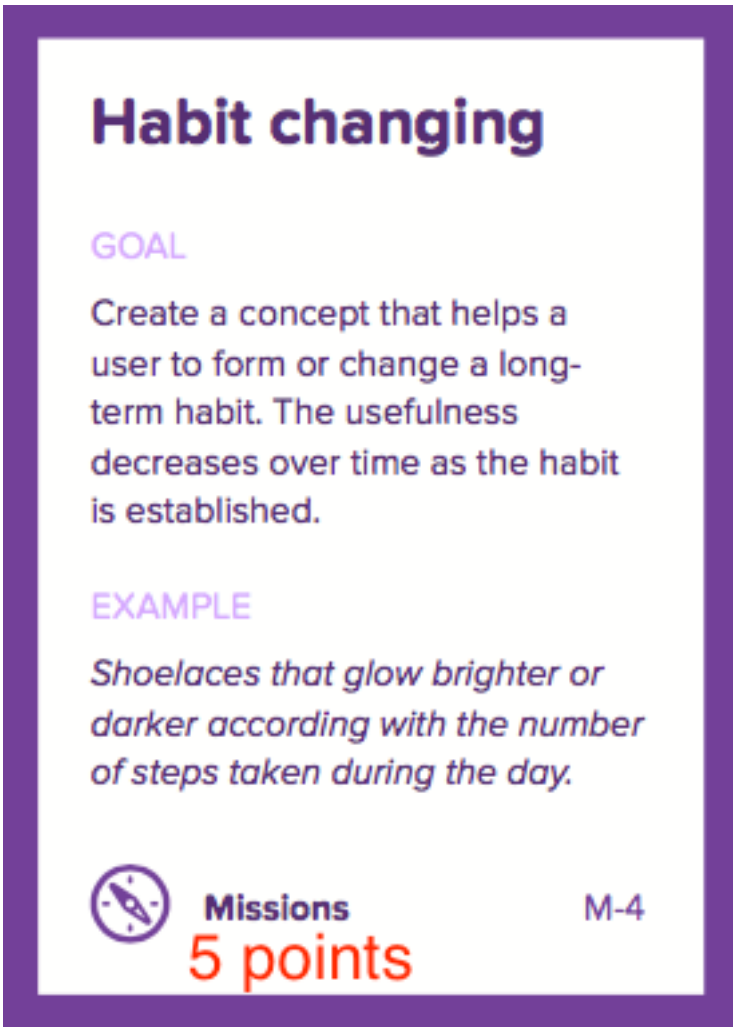

Figure 5.1 Example of a card with points.

- The game will be played in a team just like in the original Tiles. It should still learn the players about the design process, which is normally carried out in teams.

- The cards will be kept as they were in the Tiles edition that was used in the workshops with students in section 4.3.2. It will have the same categories and the same contents on them. The main difference from these workshops are the replacement of the board with the playbook and rules, and the addition of a mobile phone and the Anypawn. The board will be replaced by a much simpler board for navigation with an Anypawn with less information on the surface. The Anypawn will be the game piece the players move to progress in the game.

- The game will consist of different phases the players will have to go through in order to finish the game. Every phase will be marked with a different color on the board, corresponding to the categories of the different cards. The Anypawn has to be moved to one of the phases in order to "unlock" the cards corresponding to this phase. In this way the players have to move through every phase in the game to unlock all the cards. This is the way to complete the game.

5.5.2 Game interactions

The way the Anypawn will interact, is with the use of token events described in section 4.2. The board will have constrained regions for every phase in the design process, marked with different colors. The Anypawn has to be placed over these regions to progress through the game. Placing the Anypawn on such a region triggers a token-constraint event. The phases must be initiated in the correct order and the player cannot unlock a new phase and cards before completing the previous one. What phase to do next will be indicated both by the board and on the phone. Before a new phase begins the phone will show an explanation of the phase and what cards can be expected to find here. It will also show how much time is allocated to use on this phase. When the Anypawn is placed where it should, the phase can start by pushing the button for starting the phase. Check the sketches beneath for examples.

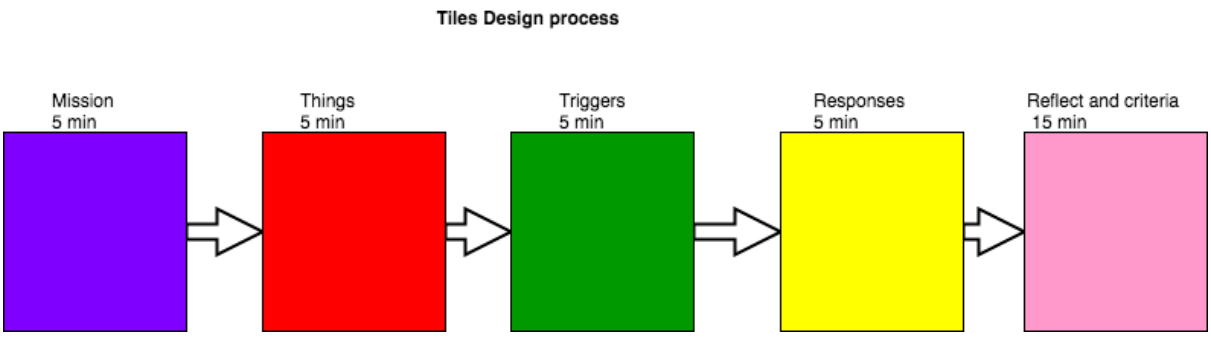

Figure 5.2 Initial sketch of theboard

Figure 5.3 Initial sketch of the view seen on the phone

- After the phase has started by the press of the button, the players can look through the cards. The Anypawn will indicate the time that is left in the phase on its display. The players have to agree on what cards and ideas they will use in each phase before the time runs out. The Anypawn will vibrate when the phase ends, and after that the view on the phone will update and the team can move to a new phase.

- After all phases are finished the score will be shown and some stats from the round of play.

5.6 Implementation and making of the game

5.6.1 The board

The first step in the creation of a functioning prototype game was making the board. The resulting board can be seen in Figure 5.4. As the first sketches revealed the game was intended to be divided into different phases. It should be logical for the player where to move and where to begin on the board. The navigation should be easy to understand and the players should be able to set the board up themselves before starting playing. The latter is the reason for the card slots that has been included on the board. I wanted to place the different card categories in a logical order and decided to associate each category with a phase. By logical order it can be seen on the board that the player start with a mission before going to the things phase, which feel natural, but of course this can be discussed. The phase located above a card slot is the phase where those cards belong to. There are one or two categories of cards associated with each phase.

The phases are squared sections highlighted by a color that corresponds with the color of the cards in that phase. They are designed this way so the player will easily identify them and the cards associated with them. The appearance should also guide the players when moving the Anypawn around on the board, and finally the appearance makes it possible for the AnyPawn to identify where it is on the board. The Anypawn used in the game shall recognize the phases by standing on top of them. Arrows lead the way between the phases and help the players move the Anypawn.

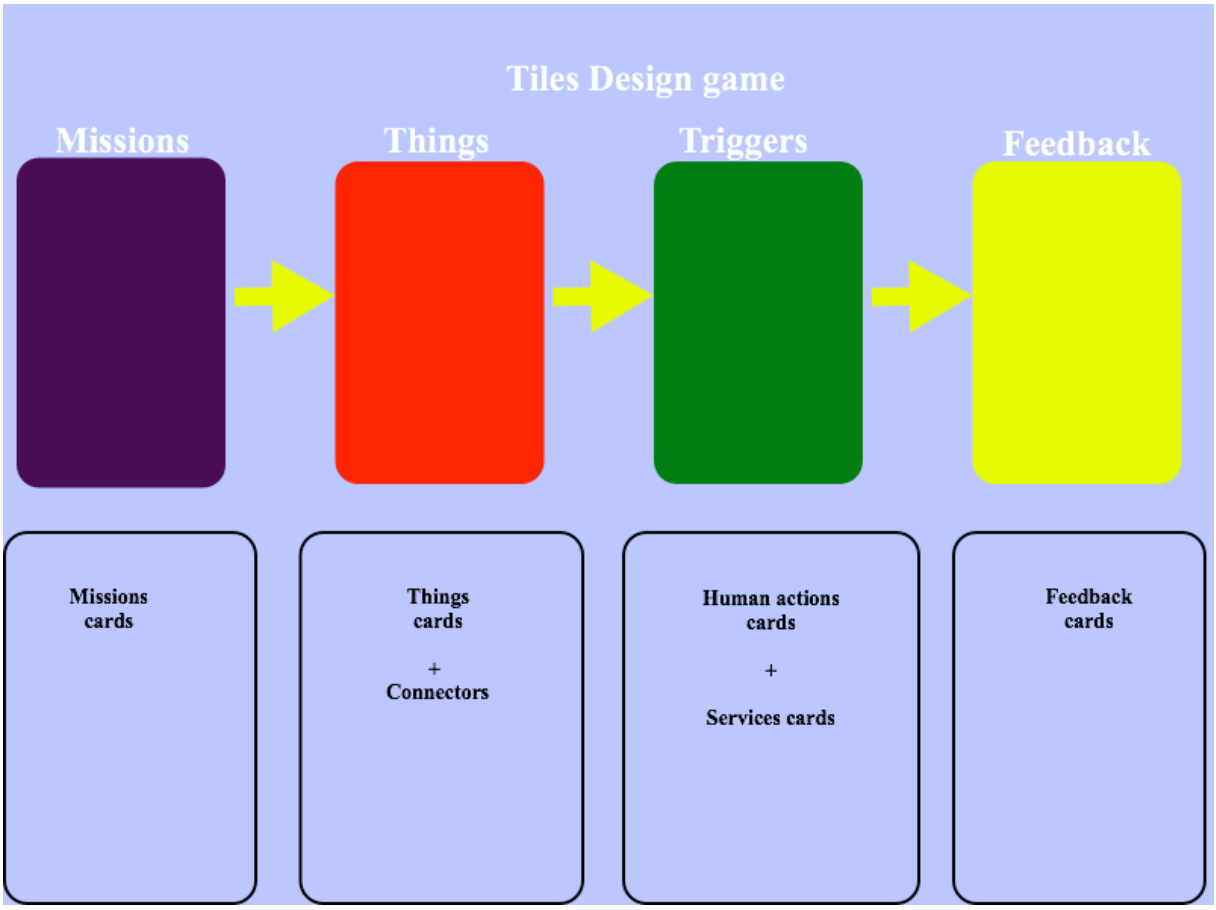

Figure 5.4 The game board of the new Tiles version

After designing the board I felt there was missing some guiding from the game on what to do with the cards and further assist the players in getting a better overview of the object they are creating ideas for. Therefore, I used some content from the original Tiles Cards and created what I call a "workbench" seen in Figure 5.5. This helps the players plan and get an overview of their ideas and add some guiding that could prove helpful when creating their smart objects.

The workbench uses the same colors as the board to identify where the players should put in work or ideas. In every phase the players have to place cards on the workbench or reach a decision they shall write down. It uses the phases from the board and map the decisions made over to sections on the workbench where I feel the cards belong. This resembles the flow that was used on the old Tiles version with the playbook, but the new version has an easy

noticeable connection between the phases and the workbench through corresponding colors, and no playbook. Also, there is card slots that indicates where to place cards.

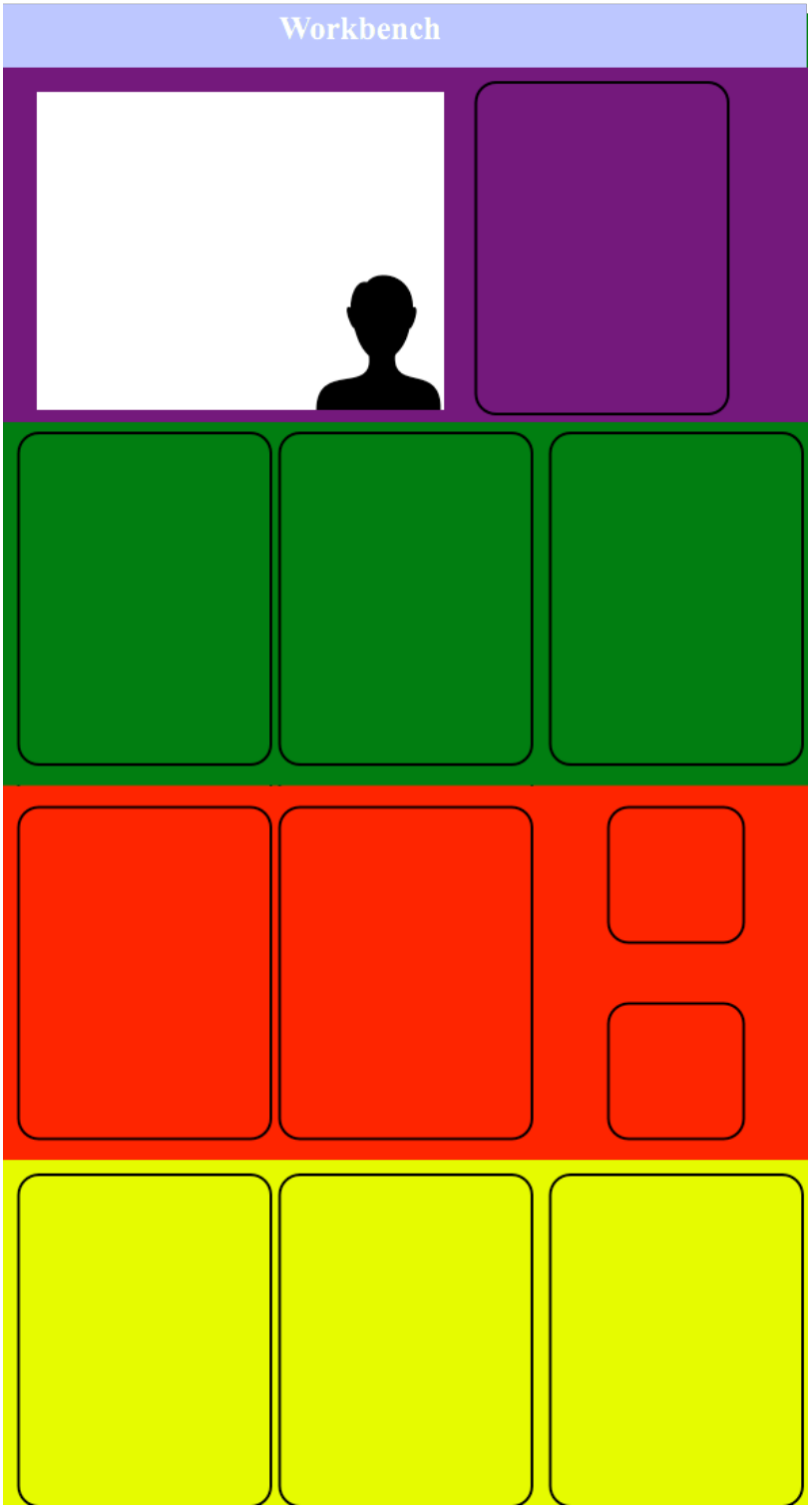

Figure 5.5 Tiles workbench

5.6.2 Anypawn

The next step in the prototyping of the game was to make the navigation and see if the game could flow and be played out as envisioned. The game would be based on the AnyBoard platform. As stated in the last section the players would use an Anypawn to progress and move through the game. Essential to this was the Anypawn's ability to identify where it was on the board and thereby recognize what phase in the game it was currently at. The way it could recognize these phases was by using the token-constraint event described in section 4.2 This was activated by placing the Anypawn on one of the colored phases on the board. Figure 5.6 shows an activated Anypawn with the proper response on the LED screen.

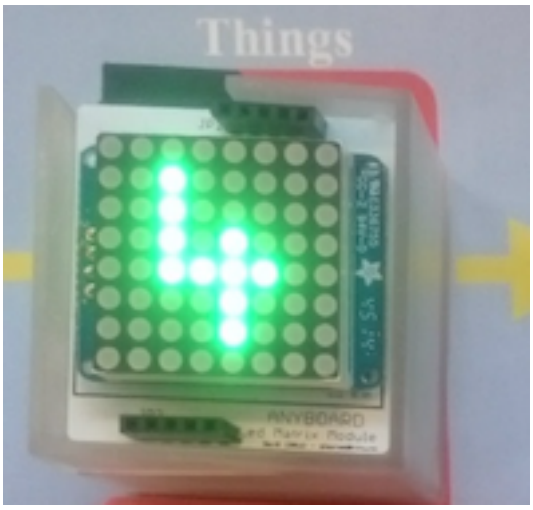

Figure 5.6 Activated Anypawn on one of the phases

Testing of the token revealed some limitations and dysfunctionalities on the Anyboard platform. Mainly, the token-constraint event proved to be unreliable and it often responded differently when testing on the same color several times. In addition, only a few selected colors seemed to be able to trigger the correct event, but only occasionally. Earlier work on Anyboard [32] and discussions with fellow students working on the platform, revealed some challenges. There were problems both with the firmware and with the hardware and it required fine-calibration in order to work. But still the recognition was too sensitive and unstable for using it in a game. As previously stated in the section of Limitations, any problems with the platform is outside the scoop of this thesis, and I will not attempt to solve them. In order to make the game flow as it should, I decided to illustrate the token-constraint event by guiding the players to the correct phase on the board, but now they had to press a

button on the interface on the phone, or tap on the Anypawn in order to activate it and start the phase.

5.6.3 Phone

The final step in the making of the prototype was implementing the phone application that would run the game logic. The application would use the Anyboard JS library to handle the interaction with the Anypawn, along with web technology to build the graphical interface displayed to the user and run the game.

The addition of the phone application was what made the biggest changes to the original Tiles Cards. Now the game was run by a phone, as a digital version instead of analogue. The players now had more game elements they needed to interact with. The phone, the Anypawn, and the board with the cards. The phone controlled the different states of the game and dynamically presented new content to the players, both on the screen and through the Anypawn. The goal I had set out was to create more absorption into the game and continuous feedback to the players. I also wanted to bring more challenge to the game. This was identified in section 4 as helpful to bring more flow to the game. The digital content introduced to the game through the phone was:

- A timer for each phase displaying the time allocated to each phase.
- A points system where the player got points for how well they did each phase.
- A Graphical User Interface (GUI) to guide the players through the game.
- Helpful instructions throughout the game the players could choose to display.

5.6.4 Timer

The timer was intended to give a time constraint to the players in each phase, to make them more focused, and also provide an element of challenge and competition. It was also intended to help them progress more efficient in the game. If the players could finish the phases quick, they would be awarded points. The exact time the users had in each phase was displayed in the GUI of the application shown in Figure 5.7. It was also blinking on the LED screen of the Anypawn in terms of minutes remaining (see Figure 5.6).

The timer was supposed to be respond to a token-constraint event, but because of unstability, two other modes was implemented. The timer could respond to either a tap on the AnyPawn or by pressing a button on the GUI. When the time had run out or the players finished the phase before the time had run out, the Anypawn would vibrate to notify the players the phase was done.

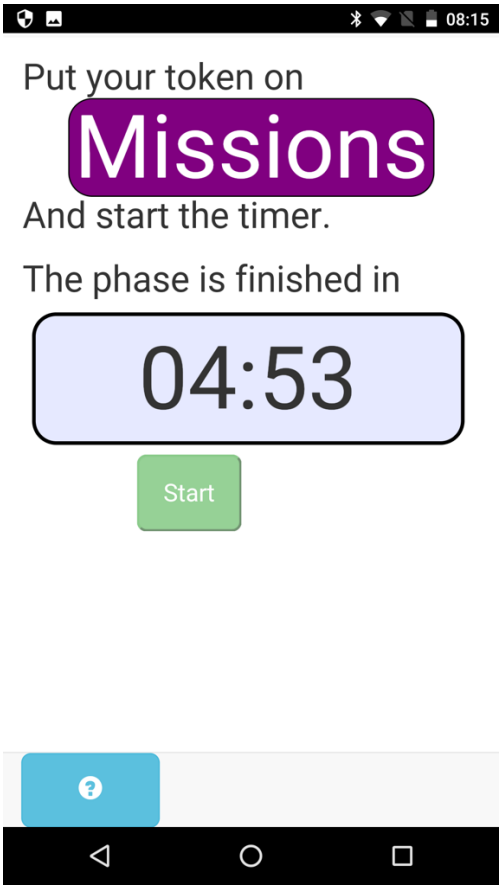

Figure 5.7 The GUI with the timer in one of the phases

5.6.5 Points system

The points system I introduced in the new version calculated points based on how much time was remaining in each phase when players moved on to the next. This was a simple points system and the score was generated on the phone requiring no user actions (see Figure 5.8). This was an example for illustrational purposes only that provided the users with immediate feedback on how the game went, and they did not have to calculate points based on card values or creativity. I considered these options in the idea phase of the Tiles game, but for this to function it requires some actions from the user. The platform in its current version has no obvious functions to detect which cards are played. Points based on time spent seems the most obvious in case of this prototype.

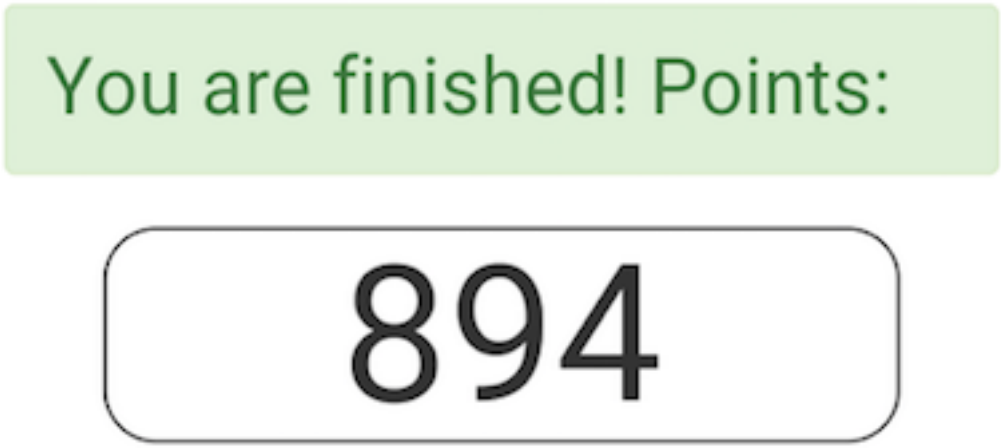

Figure 5.8. Points displayed at the end of the game.

5.6.6 Instructions

With the use of a phone, instructions were given on the screen, instead of in a manual or playbook. The instructions were given at certain points in the game and were always relevant for the task the players would do next. This way the players could make a little progress, then get instructions before they would progress further. Such an instruction can be seen in Figure 5.9. Not all information at once, so the players would feel burdened by too much information. The benefits of this is that the threshold for starting to play the game gets lowered and players can engage in the game right away instead of spending a lot of time learning how to play. The players had the option to toggle help dialogs on or off through a help button in the navigation bar.

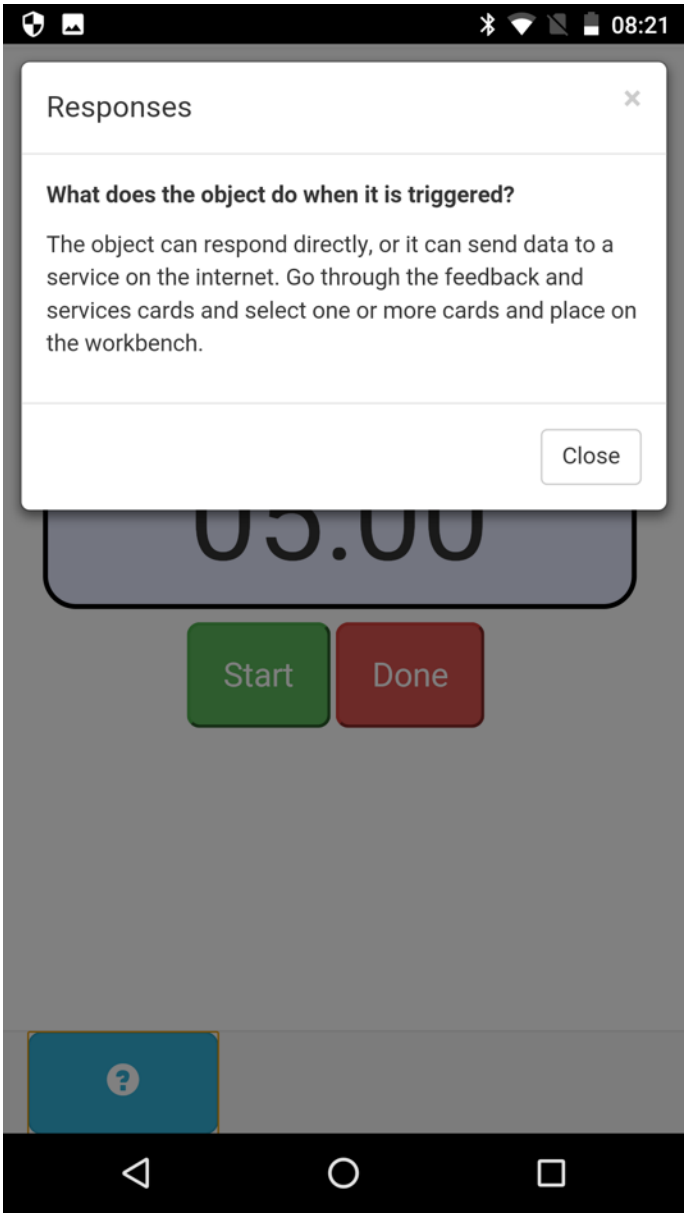

Figure 5.9. Example of instructions given to the players.

6 Evaluation

In order to evaluate the game, it was tested on different users. This section describes how the testing was performed with the feedback collected from the users

6.1 Approach

The game was evaluated in four playtests that was carried out on 1-2 users each test. Two of the tests were performed on students that had previous knowledge of IoT, and also had experienced the previous version of Tiles Cards. The remaining two playtests were on students within technical studies, but with no previous knowledge on IoT.

The setup for the playtest can be seen in Figure 6.1. Before each playtest, we had a little introduction to the game. The subject was introduced, they were given the Anypawn ant the smartphone to control and navigate in the game, and the end goal was mentioned. The introduction was kept short to see if the players were able to play up the game without much interfering, and just follow the instructions given on the phone. The players were encouraged to share their thoughts and opinions during gameplay and ask questions if something about the game were unclear. During the playtests, notes was taken of how the gameplay went and how the players approached the tasks. After each playtest was finished, we had a brief session with interviews to see what the players felt about the game, and the content it sought to teach them about.

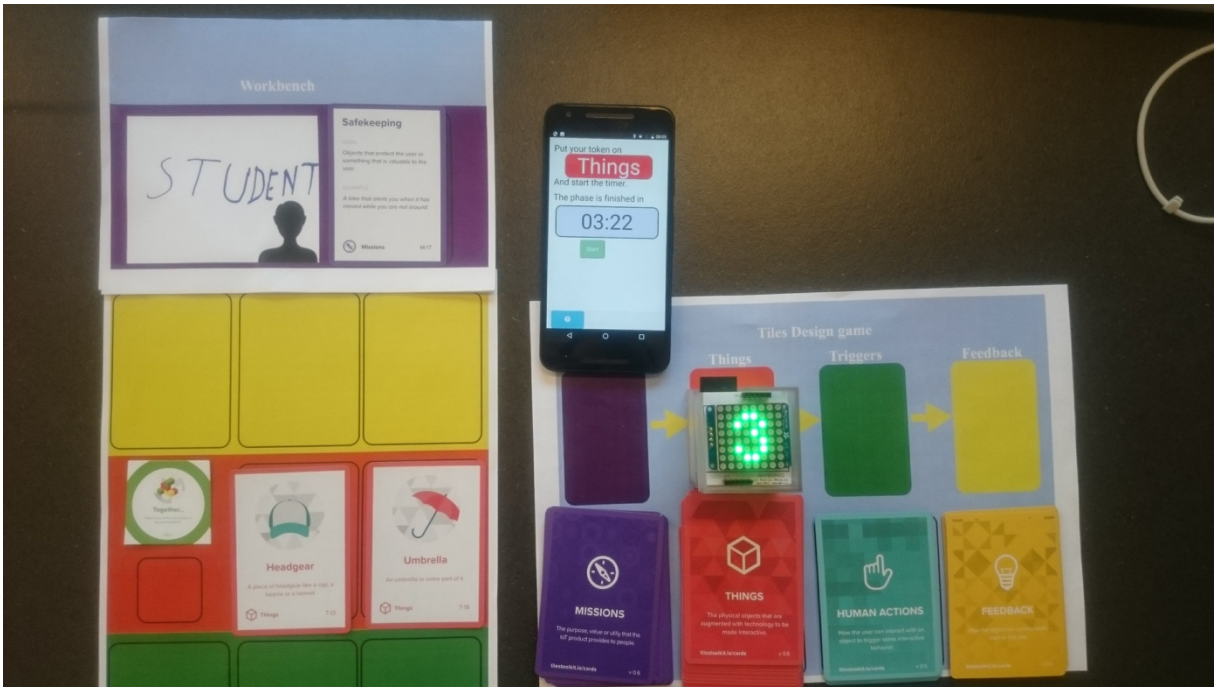

Figure 6.1. Playtest of the game

The questions given to all the players were:

1. How was the connection between the screen, the board and the Anypawn?
    a. What did you think of getting instructions on a screen to execute on the board / Anypawn?
    b. How did it influence the game flow?
    c. Were the instructions understandable?
    d. How did you feel about getting instructions at certain points in the game?
2. How did the timer influence your game experience?
    a. Was it helpful or distracting?
    b. How was the progress influenced by the timer?
3. What did you think of the point system?
    a. Did it motivate you?
4. Was the workbench helpful when designing your smart object?
5. Did you learn something about the design of smart objects? What?
    a. What in-game content did you learn from? Cards, phone or the board?
6. How did you perceive the different phases in the game?

a. Did it help you think of smart objects in another way?
b. Were the phases placed in a logical order?
c. Did they help you progress in the game?

The students that had experienced the previous version of Tiles were also asked about how they compared this to the new version.

6.2 Playtests and evaluation

The executions of the playtests were all successfully and all the teams managed to play through the game without much interfering. The teams seemed to grasp the concepts used in the game and often chose to display the instructions that were given in each phase to progress when something was not immediate clear. The color that connected the phases with the workbench was understood, and all the players navigated correctly through the game with the use of the phone, the Anypawn and the board. One group started out in one phase by placing the cards at random positions on the workbench, but realized later in the phases that the cards were placed wrong and corrected this without any guiding from me. Otherwise the execution of the playtests was successful but with a couple of connectivity issues with the Anypawn. The responses to the questions were as follows:

6.2.1 How was the connection between the screen, the board and the Anypawn?

The connection between the phone, the board and the Anypawn were understandable by the players. They agreed that the consistency with the colors that was used on screen, on the board and on the workbench made them sure about what phase they were in and how to navigate throughout the game. The use of colors and the illustration of the token-constraint event were well received and understood by the players. They quickly navigated the Anypawn to the right phases on the board per instructions from the phone. The teams all stated that getting instructions on the phone at certain points in the game made that they could start playing right away and they saved time by not having to read all the rules and instructions before playing. They also thought the instructions were clear and the game indicated in a good way when to use the Anypawn and when to shift focus back to the phone. They agreed that this caused a good flow in the game and liked the fact that they didn’t need to go back to a manual to see what to do next.

One of the student that had tried the previous version of Tiles said he liked the concept of colors and the content on the screen. He said he was curious of what would happen on the screen as he reached a new phase and what tasks to do there. The other student mentioned the game guided the player more than the previous version, and he didn't get confused on what to do next.

6.2.2 How did the timer influence your game experience?

The timer that was used in every phase of the game were perceived differently. The players were not particularly stressed when the timer was running. One reason for this were that they were given a good amount of time to complete each phase. One of the players meant a sound or music could be added to make the presence of the timer even stronger and that could add more focus to it. Some of the students thought the timer added more content which was "cool" and others didn't pay so much notice to it and instead had focus on the tasks in the phase.

6.2.3 What did you think of the point system?

The players liked the idea of getting a score to make it a more competitive game and as a secondary goal other than just designing an object, but were unsure of what criterias they would have for accomplishing points. One of the students with previous experience from Tiles Cards saw the benefit that the current points system based on time gave in terms of more engagement and effort, but mentioned also that this could shift too much focus away from the overall objective. He suggested it could be used in a sort of speed mode for generating ideas.

6.2.4 Was the workbench helpful when designing your smart object?

The workbench was used and understood by most of the players. Cards were placed correctly and in accordance with the phases. After they had been through all the phases they clearly saw the resulting design on the workbench. For one of the groups it took some time during the game to get the idea of the workbench. If they had displayed the help dialog at a previous stage in the game they would probably have got it right in the beginning.

6.2.5 Did you learn something about the design of smart objects? What?

The students with no prior knowledge of IoT reflected that they learned more about technology and the design of smart objects. They stated that the way the game and the design process was broken down in the game made them learn about the different steps of the process, and how easy it could be. Also, they learned some new technologies from the cards that could be used in the IoT field.

The other students didn't think they had learned anything new, but added that they had more fun when playing with the added digital content.

6.2.6 How did you perceive the different phases in the game?

The impression from the players were that they liked the splitting of the design process into phases. It made them quickly get into the tasks and started exchanging ideas. One thing one group noted was that they would start planning for future unreached phases. For example, they would start thinking about what objects to use when selecting a mission, before reaching the things phase. Else, the phases were reported to be logical placed in the game and gave a good overview.

6.3 Summary playtests

The playtests revealed a positive impression on the game from the players. The added content was well received and helped creating engagement, curiosity and fun to the game. The game was well understood by both experienced and non- experienced people with the IoT. The addition of the phone and the Anypawn provided a more interactive experience, as well as more guidance to the players. The game was evaluated to have a better flow and the different elements used in the game demanded more attention. The points system and the timer that was added made Tiles Cards to resemble more a game than the tool it was originally.

7 Summary and recommendations

This final section of the report will summarize the work that has been done and the results. This section also has some recommendations for further work

7.1 Summary and conclusions

This project aimed to explore hybrid games for learning and the AnyBoard platform. The objectives when starting the project was:

1. Producing a game prototype of a tool for learning about technology, called Tiles Cards developed by the institute. The AnyBoard platform will be used to make the prototype.
2. Do an evaluation of how the platform can influence learning.

Objective 1 was reached and a fully functioning prototype was produced and tested on users. Except for some limitations and problems with the platform the prototype was well received by the users.

7.1.1 Evaluation of how the platform can influence learning

The evaluation attempts to answer two of the research question set for this thesis. These were:

- RQ 1: How can AnyBoard be used to influence learning?
- RQ 2: What benefits do AnyBoard provide in terms of learning?

After making the prototype and testing it out it was clear that AnyBoard can influence learning. AnyBoard had several different ways of transfer knowledge to the user. Whether it be on the mobilescreen, on the board, through the LED screen or through cards like in the prototype. It brings more opportunities for learning new material to the players than a traditional board game. What a game developer needs to consider is how to take advantage of those added features.

When producing the new version of Tiles Cards I attempted to have most of the game happen on the table in front of the players. One of the intentions behind the creation of AnyBoard was to keep the affordances of the traditional board games. Most interactions between the players and the game should therefore not involve the phone. This is the reason, I selected to keep the

cards and have the main part of the game play out on the board. The cards ended up being the most important learning material. The usage of the phone was intended to be simple and a mean to add more excitement and fun to the game, as well as feedback and increased interactivity. That is where I believe that AnyBoard has the most potential for usage in serious games and to influence learning. AnyBoard was designed as a game platform and its features was used in my game to make it more entertaining with increased flow and more guidance. One should be careful though, as too much entertainment could reduce the learning outcome as stated in section After evaluating with the players, it revealed that the non-experienced had the most benefits from the guiding in the game.

As mentioned above the benefits that AnyBoard provided in terms of learning was increased entertainment, increased flow to the game and more interactivity with continuous feedback from the game. These factors were shown in section 2.3 to be positive within a learning environment.

7.1.2 Other games in hybrid formats

This section tries to provide an answer to the third research question.

RQ 3: What serious games and games for learning are existing in hybrid formats?

As the section of Related games and work described, there was not many serious games in hybrid formats found on the internet. A couple of games was mentioned that looked at user experience when mixing digital content together with traditional games. Don't panic could also be mentioned as an example. After browsing the internet, the impression is that hybrid games are mainly used for entertainment, and to add more interactivity and game content to new games, but also to existing games for making new versions.

Hybrid versions of Monopoly and Cluedo are mentioned in section 3.4. Those games are made to entertain the players, but could argued to learn the players about finances, or logical thinking and reasoning, even though that is not the largest focus of these games. They are commercialized games made to amuse the players, and the learning of new skills are rather supplements to the games.

7.2 Further work

There are more with the AnyBoard and hybrid platforms in general to be investigated. The AnyBoard platform could be further improved upon with more functions and technology.

What could be interesting to investigate further with the AnyBoard platform is putting more of the learning material on the GUI of the phone and provide more digital content to see how that affects learning. Of course, that could cause the game to be more like a computer game and get further away from a board game. Still, it could be interesting to see how that would impact the game experience and the learning effects.

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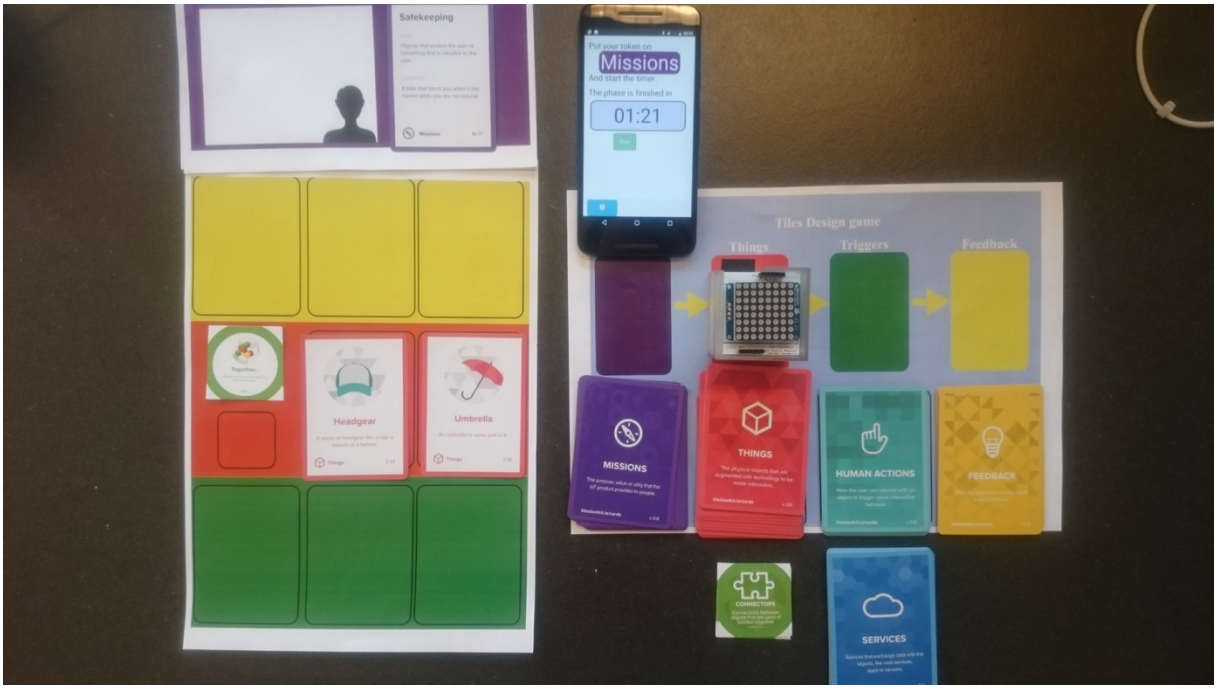
Appendix

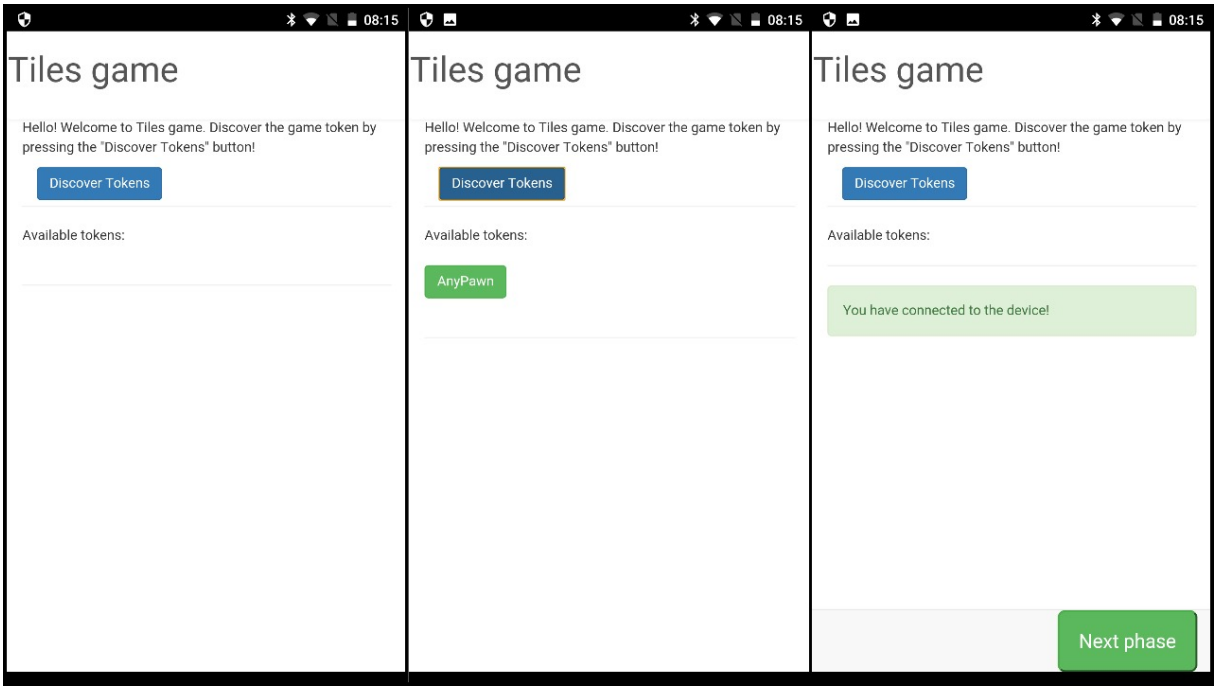
User manual

Preparations

Put the workbench and the game board on a table. Place the card decks on their indicated slots at the Tiles design game board. The workbench shall be empty at the beginning of the game. Turn on the Anypawn.

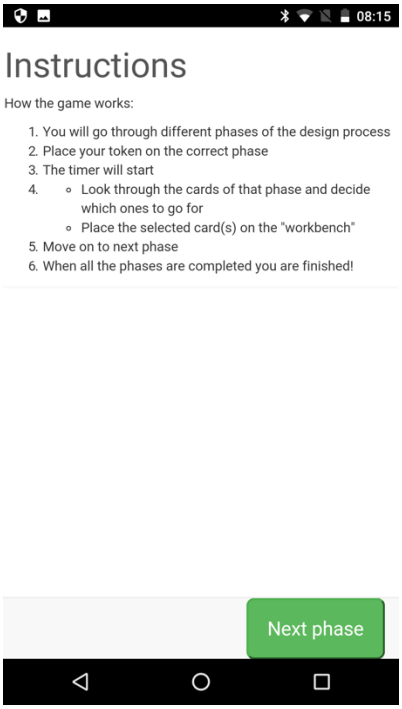


Start the application on the phone. The first screen will welcome you and help you connect with the Anypawn. Press the button discover tokens. The Anypawn will then be displayed and connect to it by tapping on it. A message will display that connection was successful.



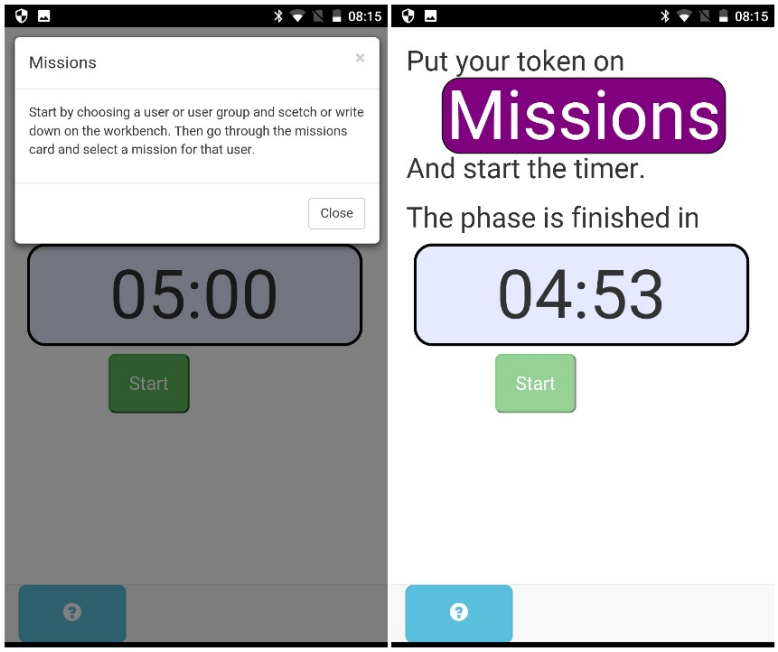
Playing the game

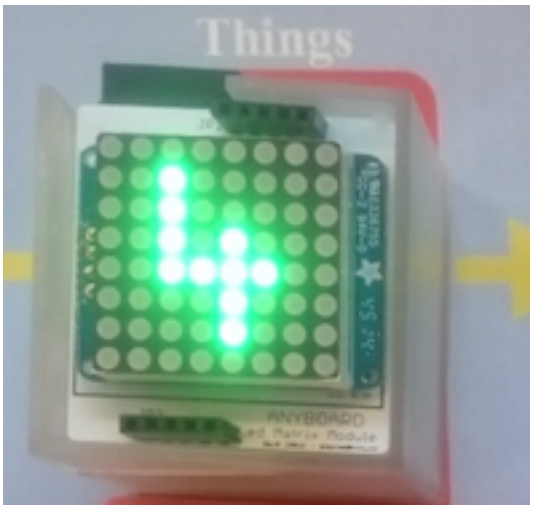
The next screen will give the players some basic instructions. How to control and what will happen. Press “next” to move on and start the game.



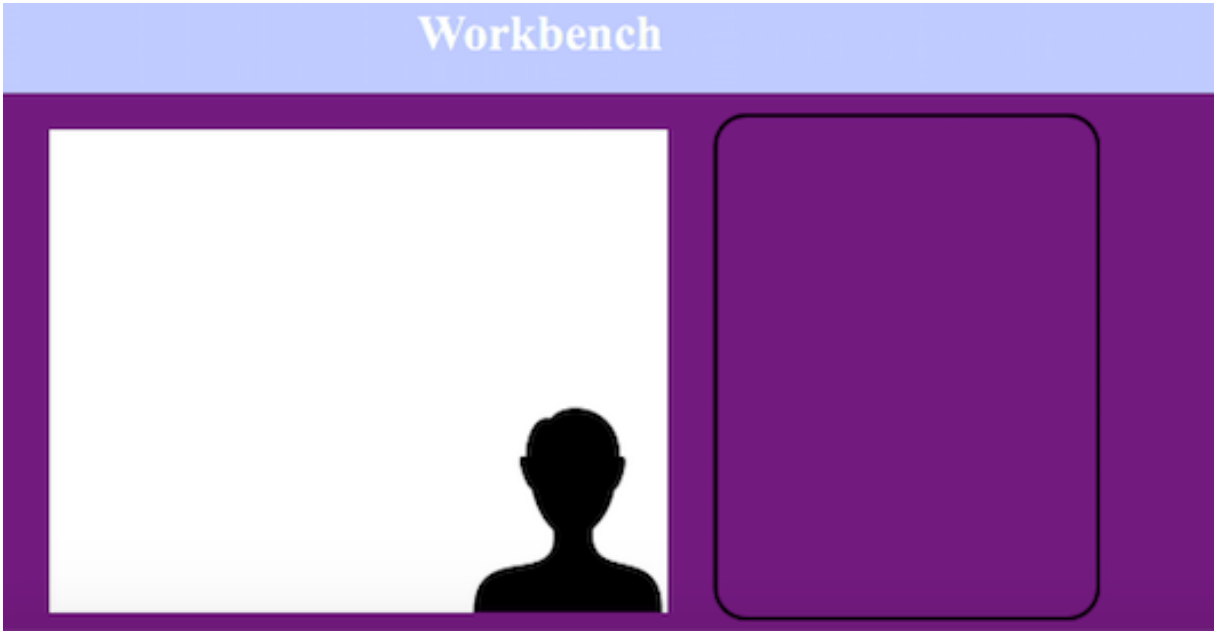
First phase

The next screen are presented. The users first get information on what to do in this phase. Place the token on the purple section on the board that indicates the missions phase in the game and start the timer. In this phase the user will choose a user for their smart object and a mission among the missions deck. They have 5 minutes to do this. The timer starts counting down on the screen and the minutes remaining is displayed on top of the pawn.





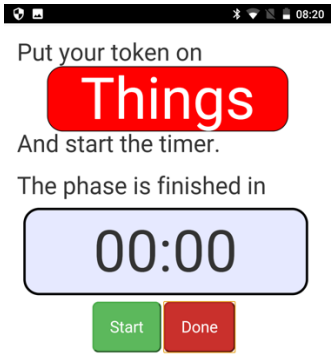
As instructed by the screen the players should place the missions card they have selected on the card slot in the mission area and write down what user they are targeting with their idea.



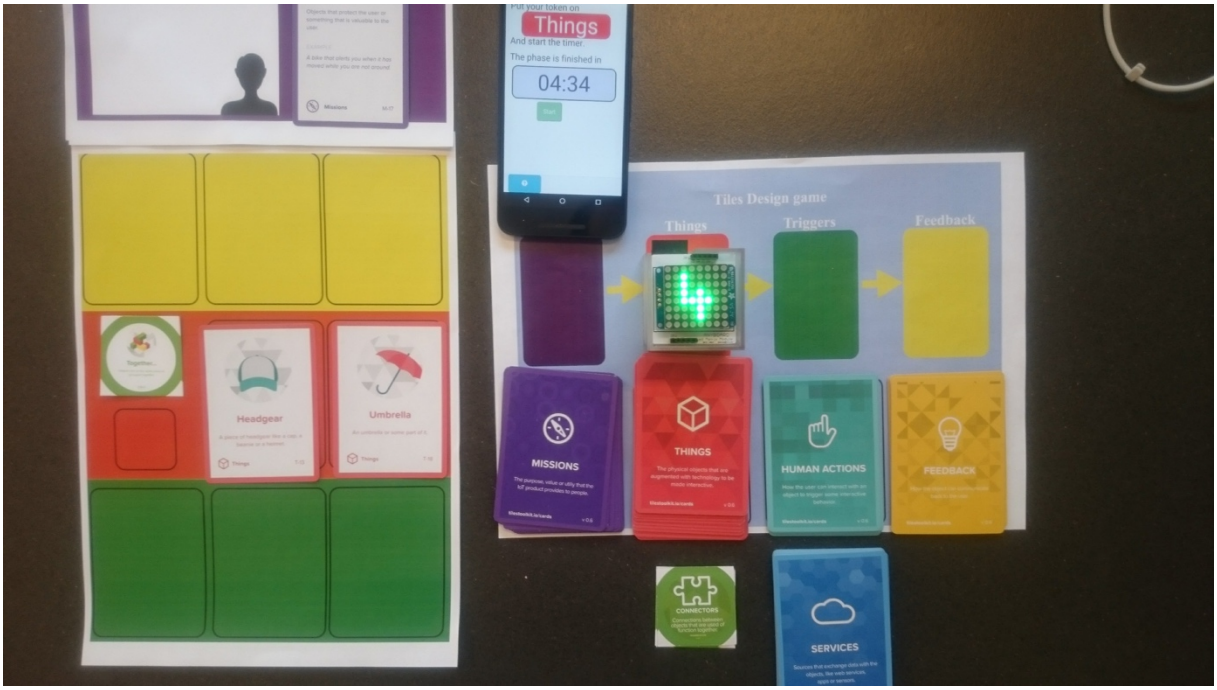
When the time runs out or the players either tap or presses the “Done” button they can head to the next phase.

Second phase

The next phase is the “Things” phase. This phase the players will not get the instructions for what to do in phase displayed automatically. Here the players can choose to display the instructions through a press of the help button in the lower left corner.



The players move the Anypawn to the correct phase and again starts the timer.



In the “Things” phase there are two decks the players can use in their design. They need to select at least one Things card to make smarter and can also decide to use multiple Things and connect them with Connectors cards. The players make their choices, place them on the workbench at the right phase, and move on to the next phase by either tapping the Anypawn or pressing the “Done” button on the screen.

The next phases are similar to the “Things” phase but with different cards. The players navigate the same way as the previous phases by moving the pawn to the correct section on the board, start the timer and selecting cards to place on the workbench. The next phases are “Triggers” and “Feedback”.

After going through all the phases the players will have made an idea to a smart object. The idea, with all the cards used in it can be seen on the workbench.

The end screen on the phone will show how many points the players accomplished this round and are based on how fast the players finished the phases.