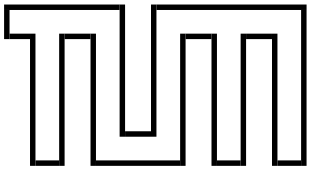


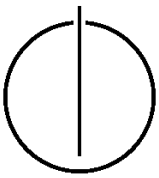
FAKULTÄT FÜR INFORMATIK

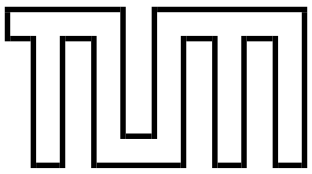
DER TECHNISCHEN UNIVERSITÄT MÜNCHEN

Dissertation in Informatik

Serious Game Patterns

Barbara Reichart





Fakultät für Informatik

Serious Game Patterns

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Lehrstuhl für Angewandte Softwaretechnik

Vollständiger Abdruck der von der Fakultät für Informatik der
Technischen Universität München zur Erlangung des akademischen Grades eines

Doktors der Naturwissenschaften (Dr. Rer. Nat.)

genehmigten Dissertation.

Vorsitzende:	Prof. Dr. Anne Brüggemann-Klein
Prüfer der Dissertation:	1. Prof. Bernd Brügge, Ph.D.
	2. Prof. Gudrun J. Klinker, Ph.D.

Die Dissertation wurde am 22.11.2017 bei der Technischen Universität München eingereicht und durch die Fakultät für Informatik am 25.02.2018 angenommen.

Zusammenfassung

Lernspiele sind interaktiv und stellen Informationen multi-modal dar als Bilder, Ton und Text. Desweiteren erlauben sie es Lernenden in einer sicheren Umgebung zu experimentieren, was ihnen die Gelegenheit gibt Fähigkeiten zu entwickeln anstatt nur Fakten zu lernen. Das gibt Lernspielen das Potential als großartiges Hilfsmittel zum Lernen. Allerdings sind Lernspiele noch nicht so weit verbreitet, wie man vielleicht hofft. Beispielsweise haben wir 136 Schüler befragt und 80% gaben an, dass sie kein Lernspiel kennen, dass sie mögen.

Bei der Analyse bestehender Lernspiele ist uns aufgefallen, dass die Mehrheit keine soziale Interaktion zwischen Spielern ermöglichen. Jedoch spielen laut der sozialen Entwicklungstheorie soziale Interaktionen eine zentrale Rolle beim Lernprozess. Zusätzlich fanden wir heraus, dass mehr als 85% der von uns befragten Schüler am liebsten mit oder gegen andere spielen. Wir denken, dass der Mangel an sozialen Interaktionen in Lernspielen ein Aspekt ist, der Lernspiele zurückhält.

In dieser Dissertation wurden mehrere Patterns für Lernspiele entwickelt, die Unterrichtenden Möglichkeiten aufzeigen, wie sie soziale Interaktionen in Lernspielen integrieren können. Die Patterns wurden anhand von existierenden Lernspielen entwickelt, die ausgewählt wurden im Bezug auf Kriterien wie Auszeichnungen, Popularität, Vielfalt und Zugänglichkeit. Zusätzlich haben wir Muster von verwandten Musterkatalogen aus dem Spieledesign und Pädagogik auf Lernspiele übertragen.

Zwei der Muster wurden im Zuge der Dissertation evaluiert. Zum einen haben wir eine Fallstudie anhand des Spiels weMakeWords gemacht mit 20 Teilnehmern. In der Studie entwickelten wir ein Spiel für Vorschulkinder, in dem sie Lernen chinesische Schriftzeichen zu lesen. Mit der Hilfe eines Kinderpsychologen haben wir soziale Interaktionen in das Spiel integriert. Indem wir einen Synchronisationspunkt eingeführt haben, ein Punkt den alle Spieler erreichen müssen bevor das Spiel weitergeht, wurde Zusammenarbeit zwischen Spielern gestärkt.

Zum anderen haben wir den Einfluss eines motivierenden Leaderboards in der Vorlesung Muster der Softwareentwicklung auf 306 Studenten gemessen. Hierbei fanden wir heraus, dass Studenten motivierter waren, wenn wir ihnen das motivierende Leaderboard zeigten. Desweiteren antworteten die Studenten zu 6% mehr korrekt und 8% schneller, was auf höhere Konzentration und besseren Lernerfolg hinweißt.

Abstract

Serious games are interactive and provide information multi-modally through images, audio, and text. Furthermore, they allow learners to experiment in a safe environment, giving them the opportunity to develop skill and not only learn facts. This gives them the potential to be great learning tools. Yet, serious games are not as widely spread as one would hope. For example, we did a survey with 136 pupils and 80% state that they do not know a serious game for learning they like.

When analyzing existing serious games, we noticed that the majority of serious games do not afford social interaction between players. However social development theory sees social interactions at the core of the learning process. We also found that more than 85% of the pupils we asked prefer to play with or against others over playing alone. We think that the lack of social interaction is one aspect that holds back serious games.

This dissertation aims to provide inspiration to educators and serious game designer on how to integrate social interactions in serious games through patterns. We elicited patterns from existing serious games selected according to criteria like awards, popularity, diversity and accessibility. Additionally we adapted patterns from related pattern catalogues from game design and educational design.

We evaluated two of the patterns. First, we did a case study on weMakeWords with 20 participants. We developed a game for preschool children on reading Chinese symbols. With the help of a child psychologist, we integrated social interaction into the game. By adding a synchronization point, a point all players have to reach before the game continues, collaboration between players increased.

Second, we measured the influence of motivational leaderboards with 306 students in the lecture Patterns for Software Engineering. We found that students were more motivated when we showed them a motivational leaderboard. Furthermore, they had a 6% higher correct answer rate and 8% faster response time, which indicates higher levels of concentration and learning.

Acknowledgments

I want to thank everyone who has supported me in writing this dissertation.

Thank you Bernd Brügge, for continuously challenging my ideas to make them better. Your enthusiasm to explore things is catching and creates a supportive environment in the chair, that allowed me to learn and grow. I am thankful for all the opportunities I got, be it to experiment with teaching methods or discussing my research at conferences. Thank you to Professor Klinker for your feedback on the dissertation.

Thank you to all my colleagues at the chair, who provided me with feedback and support. In particular I want to thank Damir Ismailović , who encouraged me to hand in my first paper and was also the supervisor for my master thesis, which would eventually start me on the journey to write a dissertation. I want to express my gratitude towards Zardosht Hodaie and Andreas Seitz for supporting me in the experimental study on the motivational leaderboard. Thank you also to the team, with whom I worked on weMakeWords: Stephan Krusche, Ludwig Schubert, and Vladislav Lazarov. I learned a lot from you. I also want to thank my office mate Stefan Nosović for teaching me all the important Bosnian curse words and for always cheering me up. Furthermore, I want to thank all coauthors of papers and articles. Thank you to Helma Schneider and Monika Markl, who with their dedication make the chair run smoothly.

Thank you, Steffi and Nessi, for giving me a decisive push when I needed it most. Thanks to all my friends who supported me emotionally through the roller coaster of dissertation writing. Finally, thank you to my whole family and especially my husband Phil for your support. Without any of you, this dissertation would not have been possible!

Contents

Chapter 1

Introduction

We don't stop playing because we grow old we grow old because we stop playing.

Oliver W. Holmes

Learning is an essential part of peoples' everyday life, long after they leave school. This can be seen when looking at the increase in in-house training, but also in the rise of online learning platforms like edx and coursera, which have several million users[1]. People are not only expected to keep up with the increasing amount of available knowledge. In addition, they need to be able to communicate that knowledge efficiently to others, to solve complex problems. While traditional learning methods like reading and studying texts allow for easy distribution of facts (declarative knowledge), they are insufficient to gain proficiency in a skill (procedural knowledge).(Blunt, 2006)

When considering findings in the field of psychology, it becomes evident why. Most learning theories agree, that learning for humans happens by abstracting from concrete evidence. But it is exactly that type of hands-on experience that is missing when studying from texts only. In games however this form of learning is prevalent. Digital games usually do not explain the complex system, which results out of their rules. Instead they show the players a few basic actions and let them experiment with those actions in environments of increasing difficulty. Psychologists like Rieber (1996) agree that "playing is a powerful mediator for learning". For example the game Civilization can be used to illustrate conflicts between nationalities. Sim City demonstrates that non-linear systems can behave in unexpected ways. Digital games can work as valuable learning tools. Serious games for learning want to make use of this.

[1] According to their own numbers coursera alone has around 15 million users (https://www.edsurge.com/news/2015-09-08-udacity-coursera-and-edx-now-claim-over-24-million-students)

Serious games have first been suggested by Abt (1970). The concept rose in popularity with the game America's Army in 2002. In the same year the Serious Games Initiative was founded (Tarja et al., 2007, p. 2).

Proponents of serious games argue that games naturally include and expect learning of skills, development of new approaches to solving a certain problem, or gathering knowledge(Gee, 2007). They do so in a safe environment that allows for an infinite number of repetitions of identical scenarios in order to experiment with different approaches or to adjust conditions in a controlled way.

Games also have a positive impact on motivation especially amongst digital natives (Lampert et al., 2009) a target group that broadens as gamers get older (Tarja et al., 2007, p. 12). As motivation can foster learning especially in the long run, serious games could be one possibility to support life-long learning.

Several attempts have been made to establish serious games as learning tools. Up until now however this has been only with marginal success. In fact Chris Crawford once uttered his frustration about serious games.(Crawford, 2003, loc. 766-768)

"Educational and childrens games have also withstood the ravages of time. Although there have been some nice entries in this category, it remains a field characterized more by hope than actuality. The failure of such games to blast off remains one of the greatest disappointments of the last thirty years."

Despite this criticism there exist a variety of successful and enjoyable serious games for learning. Unfortunately, for each of those games, there are many more which are neither educational nor fun. This can at least partially be attributed to the fact that designing games and teaching materials are already difficult by themselves. Combining them does not help the matter.

1.1 Problem

In this dissertation we extract patterns from successful serious games in order to provide ground work and inspiration for the design of new and improvement of existing serious games. In this they are similar to the design patterns catalogued by Gamma et al. (2005) for object-oriented software development. In particular, we focused on integrating social interactions into serious games.

Based on the patterns of Alexander (1987), we suggest a serious game pattern schema. We then elicitated serious game patterns for social interactions based on existing serious games and related pattern catalogues. The games were selected according to criteria like awards won, popularity, diversity and accessibility. We then evaluated two patterns exemplarily to demonstrate, how the patterns can be used and how to measure their usefulness.

1.2 Outline of the dissertation

The dissertation is organized as follows:

Chapter 2 elaborates on the foundations for serious games. It defines terms like learning, motivation, game and serious game in detail. Furthermore it provides a literature review over models of learning and motivation and how they play into the motivational power of games.

Chapter 3 defines the term patterns and discusses why they are needed and how they can improve serious games. We also show which patterns already exist for serious games and identify a lack of social interaction patterns for serious games. We define the structure of the serious game patterns and describe the process for developing the serious game patterns. After an overview of the patterns, we describe each pattern in more detail, giving its context, problem, forces, solution, consequences and examples.

Chapter 4 provides an the studies that were used for evaluation. First we describe a survey that was used to explore possible areas of research within the field of serious games. We identified social interaction as one aspect that is lacking in existing serious games. Next we describe case study that was done in cooperation with a child psychologist with the goal to increase cooperation between preschool children in a game where they could learn how to read. Finally, we evaluate the motivational leaderboard pattern in an experimental study with over 300 students.

Chapter 5 summarizes the key contributions of the dissertation and provides suggestions for future work.

Chapter 2

Foundations

On the surface, serious games seem to be a simple concept. Games are fun, to many, learning is not, hence make learning more fun by putting it into a game. However, games are not automatically fun. This can be seen in a plethora of unpopular games. Instead designing good games, specifically when they also want to provide teachings that are useful outside of the game, requires knowledge in the area of psychology, game design, and in particular serious games. In this chapter we review the most central definitions of those subject areas.

Section 2.1 defines the term learning. It then describes several learning theories in behaviorism, cognitivism, and constructivism and their implications for learning.

Section 2.2 defines the difference between intrinsic and extrinsic motivation. It then describes influences on motivation through models of motivation. The models attempt to explain, how to motivate people. In this section we want to answer the questions when and how strongly people are motivated, as well as what motivates them.

Section 2.3 defines social interactions in the context of games. In section 2.4 we develop a definition of the term game by comparing several existing definitions. In order to categories games we then create a taxonomy for games. This is followed by section 2.5 that does the same for serious games. In section 2.6 we define the term pattern, describe different pattern elicitation methods and give an overview over pattern languages related to this dissertation.

2.1 Learning Theories

During conversations many people refer to schools and sitting in front of a book when talking about learning. However while studying is one way to learn, most learning takes place outside of those formal contexts in a more tangential way. Learning always takes place, it is almost impossible not to learn on a daily basis.

When trying to optimize learning experiences, it is important to know what to teach and understand what learning is, and how it occurs. In this chapter we give a short overview over the most critical psychological aspects of learning, starting with a definition and then explaining learning theories as well as pedagogical models based on those theories.

Before diving into models of how people learn, we need to define the term learning. Illeris (2007, p. 3) defines learning as

> "any process that in living organisms leads to permanent capacity change and which is not solely due to biological maturation or aging."

This definition highlights a few interesting points. First of all learning leads to a change in behavior or ability. This means it is observable by an outsider. Second, this change is permanent. This means it is not a sufficient indicator for learning that a person shows a newly learned behavior once, for example under supervision, but instead they have to show it several times over a longer period of time. Last, the definition distinguishes learning from biological maturation. Development is an umbrella term for learning and maturation.

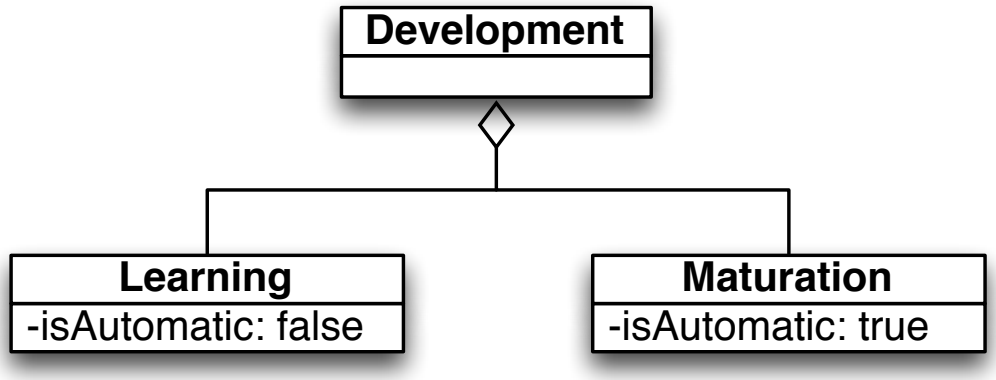

Figure 2.1: Learning is a part of development

In this section we will provide a brief overview over the most prevalent learning theories. There we will see that learning is a complex process with several contributing factors and that "there is no automatic link between teaching and learning".(Illeris, 2007)

2.1.1 Behaviorism

According to the definition of learning it leads to a permanent capacity change, which is observable. Behaviorism entirely concentrates on those observable changes

achieved through reinforcement, thus treating the brain and its learning process as a black box. "It [...] sees peoples thinking and learning as a response to stimuli from the environment"(Skinner, 1985). Man is a machine, "dependent on external stimuli to function" (Reynolds et al., 1996, p. 95). Behaviorism was a reaction to "mentalistic psychology", which was criticized for its lack of reproducability.

This problem is what Watson addresses when he writes: "[...] I believe, during the fifty-odd years of its existence as an experimental discipline to make its place in the world as an undisputed natural science. Psychology, as it is generally thought of, has something esoteric in its methods. If you fail to reproduce my findings, it is not due to some fault in your apparatus or in the control of your stimulus, but it is due to the fact that your introspection is untrained."(Watson, 1913)

Figure 2.2: Black box view on learning as seen by behaviorists

By reducing the learning process to a combination of inputs and outputs, also called conditioning, researchers were enabled to validate theories about effective learning through quantitative experiments. Most important are the experiments by Pavlov (1927), Thorndike (2006), and Skinner (1938). Their observations are still seen as giving meaningful insight into learning, hence we will give a brief description over the experiments and their results.

Classical Conditioning Classical conditioning links an unconditioned stimulus (US), e. g. food that triggers saliva production in dogs, to a conditioned stimulus (CS), e. g. the ringing of a bell, by repeatedly presenting both stimuli together.

In his experiments Pavlov rang a bell and then fed the dogs. After several repetitions the dogs would start to salivate at the ring of the bell even when they were not handed any food. Pavlov showed that presenting the conditioned stimulus briefly before the unconditioned stimulus is most effective. Furthermore, he observed that presenting the unconditioned stimulus without conditioned stimulus the dogs returned to their pre-training level. This effect is called extinction.

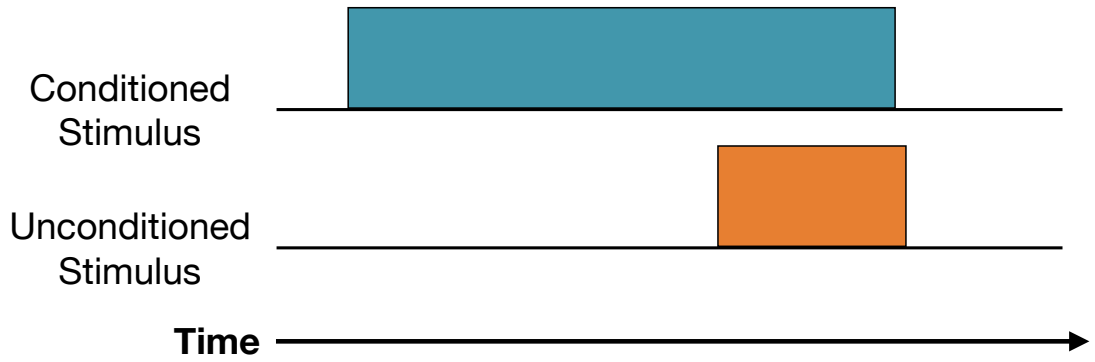

Figure 2.3: Delay conditioning - classical conditioning method where the CS is presented briefly before the US (adapted from Gernot Horstmann (2012, p. 15))

Operant Conditioning In contrast to classical conditioning operant conditioning focuses on the learning of conscious behaviors, which are reinforced by rewards and punishments.

Thorndike (1927) was the first to research operant conditioning. He built a puzzle box that cats had to escape from through a simple action like pulling a rope or pushing a pole. Additionally the box offered several useless interactions. Thorndike observed that in the beginning cats would require a large set of ineffective trials until they could escape. In further trials, cats would display ineffective behaviors less frequently and successful behaviors more frequently, hence escaping the puzzle box more quickly. Thorndike generalized this observation into his law of effect, which states "that what comes after a connection acts upon it to alter its strength."(Thorndike, 1927)

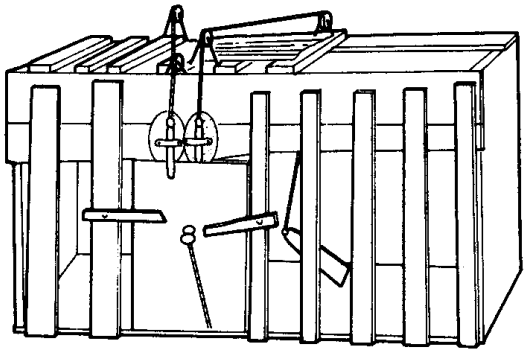

Figure 2.4: Thorndikes cage (Thorndike, 1898, p. 8)

This idea was later refined by Skinner. He used an operant conditioning cham-

ber, where rats or pigeons could execute one or two repeatable actions. This enabled Skinner to measure the rate of responses, allowing him to evaluate reinforcement schedules. A reinforcement schedule is defined as "any procedure that delivers reinforcement to an organism according to some well-defined rule."(Staddon and Cerutti, 2003)

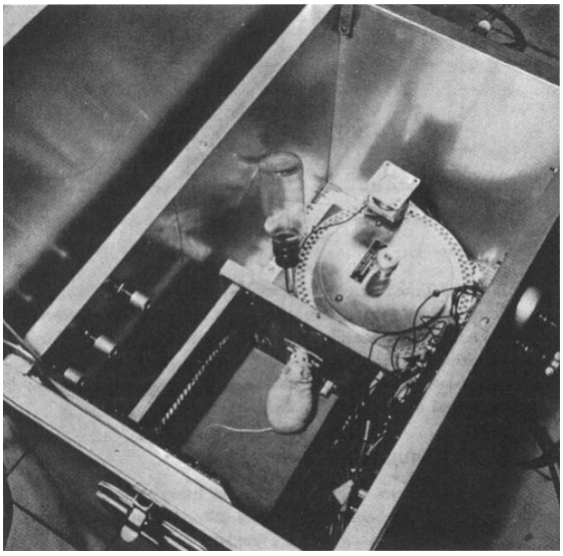

Figure 2.5: The operant conditioning box allows to measure the frequency of a behavior with regards to a reward schedule (Skinner, 1999, p. 159)

Reinforcement schedules are mainly classified by the condition for reinforcement. The first type is a ratio schedule, where the reinforcement is contingent on behavior. The second type is an interval schedule, where the reinforcement is contingent on time. Another classification criteria is the regularity with which the reinforcements are given. Rewards are either given after a fixed or variable rate or interval.

This means there are four categories of reward schedule. In the fixed-ratio schedule, behavior is reinforced after a specific number of responses. One example for this are sales-bonuses, where salesman receive a reward every time they close a new deal. The variable-ratio schedule also rewards behavior, but after an average and unpredictable number of responses. Gambling in a casino for example follows a variable-ratio schedule. In fixed-interval schedules, the reward is given in fixed time intervals as long as the behavior is shown. The most common example for this would be monthly wages. The variable-interval schedule rewards behavior after variable, but unpredictable amounts of time. Checking for emails is one example for this type of reward schedule.

The four different reward schedule differ both in how quickly they condition

certain behavior and also how quickly the trained behavior is extincted again. Figure 2.6 illustrates the relation between reward schedule, time, and frequency of the trained behavior.

It can be seen that reinforcements dependent on behavior lead to a stronger reaction. Furthermore, researchers found that extinction of a learned behavior is slower for variable reward schedules than for fixed reward schedules.(Stangor and Walinga, 2014, p. 347) In all cases the frequency of the learned behavior is reduced, if there is no more reinforcement.

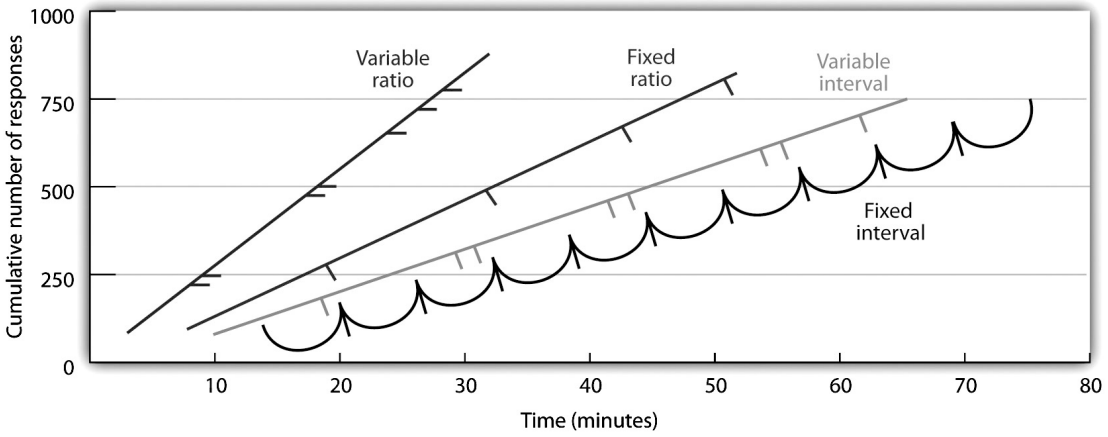

Figure 2.6: Reinforcement schedules and their effect. The small diagonal lines indicate the time of the reinforcement. We can see that reward schedules based on behavior instead of time are more effective. (adapted from Stangor and Walinga (2014, p. 364))

2.1.2 Cognitivism

Cognitivism extends Behaviorism by taking internal mental states into account, as the simplistic learning models that resulted from behaviorist theories could not explain certain types of learning. Most notably, Chomsky argued that learning a language cannot be achieved solely through rewards and punishment.(Chomsky, 1957, 2004)

Furthermore, psychologists realized that humans have certain biases in how they perceive and retain information. For example, humans usually see a face instead of an oval and two straight lines when looking at figure 2.7. Even infants 3 months of age and younger utilize the gestalt principles of organization.(Quinn et al., 2002)

For researchers it became clear that simple stimulus-response training cannot explain some phenomena. "Frederic Bartlett discovered that people made system-

atic errors when trying to recall [...] stories. He proposed that human memory is an active, constructive process, in which we interpret and transform the information we encounter."(Matlin, 2014)

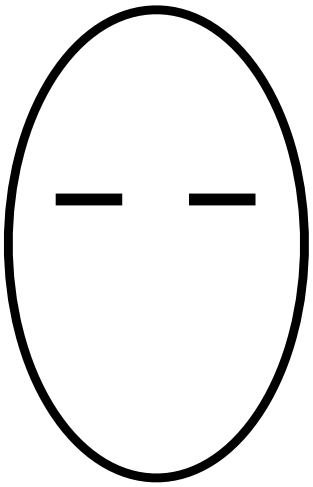

Figure 2.7: An example of Gestalt Psychology. What do you see? (adapted from Matlin (2014, p. 6))

This view on learning and memory was supported by the developmental researcher Jean Piaget. According to Piaget children actively explore their world in order to understand important concepts, applying changing cognitive strategies as they become older.(Gregory, 2004) Piaget observed several developmental states common to most children and independent from individual conditioning.

Cognitivism does not treat the brain as a black box. Instead it compares mental processes to the operations of a computer. This is sometimes referred to as the information-processing approach.(Matlin, 2014, p. 9) Researchers in the field of cognitivism analyze how the brain processes stimuli, how it retains them in memory, and how it applies them to problem solving. Knowledge of those processes can help improve the design of serious games for learning, as it can make concrete suggestions on how to optimally present visuals or organize information to be processed effectively.(Yilmaz, 2011; Schneider and Stern, 2010) The next section summarizes effective design suggestions for learning environments on perception, memory, and problem solving.

Perception Perception is the "use of previous knowledge to gather and interpret stimuli registered by the senses."(Matlin, 2014, p. 505) In behaviorism this processing step is reduced to noticing an external reinforcement. However, research in cognitivism shows that even identifying objects in our environment is a complex

task and that we usually do not perceive all parts of our environment with the same level of detail. Instead perception is influenced by information processing, attention, and consciousness.

Information processing in the human brain is done bottom-up as well as top-down. Bottom-up processing focuses on physical stimuli, while top-down processing focuses on how expectations and memory influence perception. Top-down perception is especially useful when dealing with incomplete information or information that is only briefly available.(Groome, 1999) It is important to note that top-down processing can lead to cognitive mistakes.

For example, humans tend to have difficulties detecting change in an object or a scene, when the overall structure stays the same. This is referred to as **change blindness**.(Levin, 2004) Furthermore, humans display **inattentional blindness**, missing an event when they are paying attention to another expected event.(Most et al., 2005)

Both effects can be overcome by a teacher guiding attention towards those blind spots. This can be done by explicitly stating learning goals before presenting any content and taking into account preexisting experiences.

Memory Cognitivism distinguishes between two types of memory. Working memory can hold only a strictly limited set of memories for a short time, which it makes accessible for ongoing mental activities. Long-term memory in contrast has a large capacity containing experiences and information collected in the past. Transfer of information from working memory to long-term memory is not automatic, but strongly filtered. Both capacity of the working memory and information storage have important implications for designing learning environments.

Short-term memory is limited. Miller (1955) observed it is limited to seven items (plus/minus two) for an average adult. This number can be increased with two different techniques.

Chunking is "a memory strategy in which the learner combines several small units to create larger units".(Miller, 1955) For example, remembering the number 31122015 is difficult, when trying to remember each digit by itself. However when labeling it as the date of New Years Eve 2015, it is easier to remember as it takes less slots in the working memory. Whenever possible designers should therefore chunk data under a descriptive label.

Utilizing **independent capacities** can also increase the amount of information the working memory can handle simultaneously. For example, Baddeley and Hitch (1974) found out that people are surprisingly effective at performing a spatial reasoning task and memorize numbers at the same time. This means that information presented with different modalities (e.g. text and picture)

can increase the amount of information that learners can handle simultaneously.

Long-term memory is much less limited. However, only a small part of our observations is stored there, while the rest is dismissed as irrelevant. As memorization over long periods of time is essential to learning, we will highlight a few points that influence, which information is retained.

Research shows that information is remembered more effectively when it is processed at a deep level. This is due to the two factors elaboration and distinctiveness.

Elaboration refers to processing memories in a way that emphasizes the meaning of a particular concept as well as relating it to prior knowledge.(Matlin, 2014, p. 129) For example one can learn by heart that ADSL (asymmetric digital subscriber line) has more download than upload. However, understanding that it was designed this way, because people download a lot more than they upload, makes it easier to remember that information.

"**Distinctiveness** means that a stimulus is different from other memory traces."(Matlin, 2014, p. 129) Information can mainly be distinct either through importance or frequency of occurrence, where importance is a subjective rating of the information. This can be especially seen with regards to the self-reference effect. According to this effect, people are more likely to remember information if they relate it to themselves (Burns, 2006; Gillihan and Farah, 2005; Schmidt, 2006). Also information that is loaded with emotions is remembered more vividly, with pleasant memories being the most endurable. Creating an emotional connection can be achieved by applying a narrative to the information. Bower and Clark (1969) showed that studying a set of English words was twice as effective when participants were instructed to make up a narrative story that includes those words.

Problem-Solving Problem-solving requires several cognitive processes to play together. First of all, it is necessary to understand the problem and focus attention to the appropriate part. Second, the problem needs to be connected to the appropriate memories. Cognitivism suggests strategies that help learners to improve problem-solving skills. Here we focus on two aspects: transfer and metacognition.

Transfer refers to solving a structurally similar problem within a new setting. Unfortunately, people mostly focus on superficial surface features, instead of noticing structural features.(Bassok, 2003; Bernardo, 2001; Whitten and Graesser, 2003) Especially isolated facts are only transferred rarely. In order to facilitate transfer, learners should try several structurally similar problems in a variety of situations. This helps the brain to form generalizations. Furthermore, teachers should emphasize the structure of the underlying problem. For example, students

solve statistics problems more accurately if they have been trained to sort problems into categories on the basis of structural similarities.(Quilici and Mayer, 2002)

Furthermore problems should be provided under a unifying theme, ideally even an authentic situation. Otherwise it might be too abstract to understand or worse, it might even be assigned to the wrong schema.(Vygotsky, 1978; Yilmaz, 2011)

Metacognition means the "knowledge and control of cognitive processes." (Matlin, 2014, p. 504) There are certain learning strategies and cognitive processes that help improve memorization and applicability of knowledge. While it is important that educators know about them and integrate them into their teaching, students should also be shown how to select and use appropriate learning strategies such as summarizing, questioning, and reflection.(Wilson et al., 1993)

Resulting learning models Cognitivism has provided insight into how humans perceive, memorize, and apply information. The theories developed in that context informed several pedagogical models that provide suggestions on how to approach teaching. For example cognitive apprenticeship, reciprocal teaching, anchored instruction, inquiry learning, discovery learning, and problem-based learning. Brief summaries of those can be found in Yilmaz (2011).

2.1.3 Constructivism

Constructivism evolved from cognitivism. It postulates that there are no objective truths, instead learners discover and construct knowledge based on experience. (Popper, 2005; Crotty, 1998; Fosnot, 1996; Hendry et al., 1999) As such "constructivism advances meaning-making and knowledge construction as its foremost principles (Crotty, 1998; Fosnot, 1996; Phillips, 1995)."(Yilmaz, 2008)

The assumption that knowledge is not objective has far-reaching implications for teaching. Learners need to be considered active individuals rather than vessels to be filled. Learning cannot be seen as a mere transfer of materials from teacher to learner. Instead posing questions, solving problems, and constructing theories lies at the core of learning. Because of this constructivism places emphasis on discourse facilitated by both teachers and learners.(Maclellan and Soden, 2004)

The goals of constructivism are to focus on individual students developing deep understandings in the subject matter of interest and habits of mind that aid in future learning, for example through "authentic" tasks, as the goal of instruction.(Fosnot, 1996, p. 10-11) Some constructivists even claim that effective learning requires meaningful, open-ended, challenging problems for the learner to solve. (Boethel and Dimock, 1999; Fox, 2001) This idea is supported by Carlson: "People learn best when they are entertained, when they can use creativity to work toward complex goals, when lesson plans incorporate both thinking and emotion, and when the consequences of actions can be observed".(Carlson, 2003)

Resulting learning models Teaching models based on constructivism are learner centric. The task of the teacher is to provide a suitable learning environment and steer the learning process by identifying misconceptions and reacting accordingly.

Brooks and Brooks (1999, p. IX-X) describe the pillars of constructivist pedagogy and the characteristics of constructivist teaching practices. Constructivism focuses on posing problems of emerging relevance to learners. It acknowledges that relevance and meaning are not automatically embedded in topics, instead they arise from the learner himself. For example, when learning how to read, the teacher could allow a student to pick their own reading material. Additionally, constructivism structures learning around primary concepts instead of presenting the material in small disconnected parts. This allows learners to gain a bigger picture instead of simply memorizing facts. Furthermore, teachers should seek and value a learners' points of view. The curricula should be adapted to address students suppositions. This means the teacher tries to find out current conceptualizations of her students and then either supports or contravenes those suppositions. Lastly, constructivism postulates that assessment should be embedded in the context of teaching and not be seen as separate from learning.

Teaching models of constructivism include experiential learning, self-directed learning, discovery learning, inquiry learning, problem-based learning, and reflective practice. (Yilmaz, 2008; Mcleod, 2001; Wilson et al., 1993; Slavin, 2011)

2.2 Motivation

Understanding motivation is an essential key to understanding gaming and learning behaviors in humans. As such motivational psychology forms an essential basis for the work on serious games.

2.2.1 Definition

Motivation is "the willingness or desire to engage in a task [...]".(Garris et al., 2002) "A person who feels no impetus or inspiration to act is thus characterized as unmotivated, whereas someone who is energized or activated toward an end is considered motivated."(Ryan and Deci, 2000a)

However motivation is not simply binary. A person is not either motivated or not motivated. Instead motivation can vary in level of intensity and in persistency. Furthermore, motivation depends on the task at hand. For example a person can be motivated to do the dishes, but not to mow the lawn.

The reason why someone is motivated to do something can differ. For example the person is motivated to do the dishes to show off his clean home to a guest, or

because he understands the utility of having a hygienic kitchen. In these examples the intensity, persistence, and behavior stay the same, but the reason behind the motivation clearly does not.

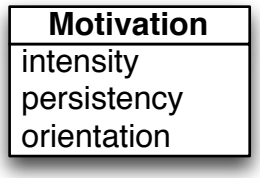

Figure 2.8: Motivation is defined by its intensity, persistency, and orientation.

Psychologists distinguish between intrinsic and extrinsic motivation. In short, intrinsic motivation refers to "doing something because it is inherently interesting or enjoyable"(Ryan and Deci, 2000a), and extrinsic motivation refers to doing something "because it leads to a separable outcome."(Ryan and Deci, 2000a)

Intrinsic

"Intrinsic motivation is defined as the doing of an activity for its inherent satisfactions rather than for some separable consequence"(Ryan and Deci, 2000a). This means the person acts out of their own will rather than being pushed by external pressure, punishments, or rewards. It was discovered in experimental studies on animal behavior, which showed that many organisms engage in exploratory, playful, and curiosity-driven behaviors even in the absence of reinforcement or reward.(White, 1959)

While nearly every person shows this behavior, there is a large variety between activities that lead to intrinsic motivation. For some people training for a marathon can be highly engaging, whereas others prefer to stay at home and play computer games.

There are two explanations why an activity is intrinsically motivating. They are based on two dominant behavioral theories:

Operant theory (Skinner, 1953) suggests rewards as basis for all motivation (for more information see above in subsection 2.1.1). In such a model intrinsically motivated behavior would only occur if the activity is a reward in itself. This explanation requires researchers to find out what inherent properties make an activity interesting and rewarding. The appeal for those task can stem from novelty, challenge, or aesthetics.

Learning theory (Hull, 1943) models physiological drives and their derivatives as the driving force of all behavior. Thus intrinsically motivated activities seem to provide the satisfaction of innate psychological needs. Examples of psychological needs identified by research are competence (Ryan, 1982), autonomy (Vallerand and Reid, 1984), and relatedness.

Intrinsic motivation is a large contributor to successful learning. For example, students who are overly controlled not only lose initiative but also learn less well, especially when learning is complex or requires conceptual, creative processing.(Benware and Deci, 1984) Whereas children given autonomy are more likely to spontaneously explore and extend themselves.(Grolnick et al., 1997)

Feelings of competence can be relayed by "optimal challenge, effectance promoting feedback, and freedom from demeaning evaluations".(Ryan and Deci, 2000a) Autonomy can be increased by giving the opportunity of choice and self-direction.(Zuckerman et al., 1978) Unfortunately most straightforward ways to influence the behavior of a person, could be perceived as a reduction of their autonomy, thus reducing motivation. For example the "overjustification effect" (Steiner, 2011; Deci, 1971; Lepper et al., 1973) demonstrates that extrinsic rewards can potentially undermine intrinsic motivation.

For example Steiner (2011) gave participants an interesting spatial-relations puzzle called Soma. In the first phase of the experiments, participants were asked to solve four puzzles. At the end participants received a reward. The first group received a task-congruent reward, a wooden take-home Soma puzzle. The second group received 5€, a task-incongruent reward. The last group did not receive any reward. The reward was independent of performance during the puzzle solving phase. In the second phase, participants were told that they just briefly had to wait and could do whatever they wanted. They could read a magazine, play with their phones, or simply sit and wait. With the video camera the researches recorded how long the participants continued to play with the Soma puzzle. The results of the study can be seen in 2.9. It can be seen that both types of reward lead to decreased interest in the task, where the task-incongruent reward has the most negative impact on motivation.

A reduction in motivation can also be observed for threats (Deci and Cascio, 1972), deadlines (Amabile et al., 1976), directives (Koestner et al., 1984), and competition pressure (Reeve and Deci, 1996).

Extrinsic

Many activities are extrinsically motivated by social demands and roles. The driving force behind extrinsically motivated behavior is not an inherent interest in

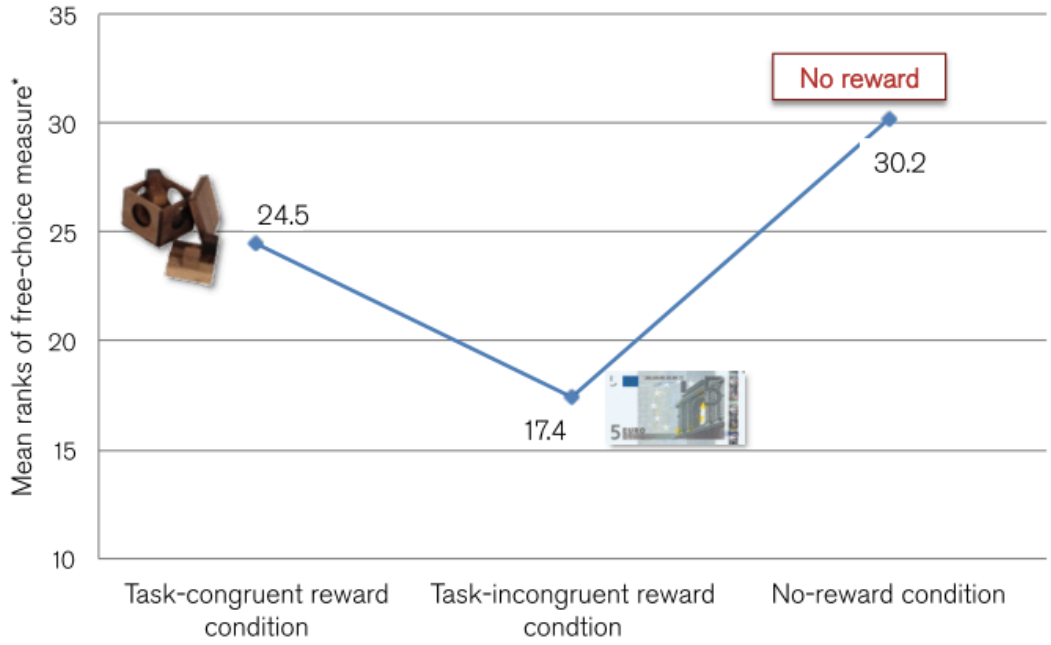

Figure 2.9: Experimental results demonstrating the overjustification effect.(Steiner, 2011)

the activity itself, but instead in achieving a goal. This goal could either be the avoidance of negative consequences or the hope for rewards.

"In the classic literature, extrinsic motivation has typically been characterized as a pale and impoverished (even if powerful) form of motivation that contrasts with intrinsic motivation.(DeCharms, 1968) However, newer research proposes that there are varied types of extrinsic motivation, some of which do, indeed, represent impoverished forms of motivation and some of which represent active, agentic states."(Ryan and Deci, 2000a)

For example doing homework solely out of fear to be reprimanded is a behavior mainly driven by compliance to an external control. Doing homework to further one's career is also extrinsically motivated, but entails a much higher personal endorsement and feeling of choice. This means that tasks cannot strictly be separated into extrinsic and intrinsic tasks, but rather align along a continuum. Those stages are named (from extrinsic to intrinsic): motivation, external regulation, introjected regulation, identification, integrated regulation, intrinsic motivation.

"Usually with increasing internalization (and its associated sense of personal commitment) come greater persistence, more positive self-perceptions, and better quality of engagement."(Ryan and Deci, 2000a)

2.2.2 Models of Motivation

Motivation is not binary. Instead, people display severe differences in intensity and persistence of motivation. Motivations differ not only between people, but also fluctuate for a single person with time and task. What factors have to be fulfilled to lead to high levels of motivation?

Several models of psychology attempt to answer the question what factors lead to differences in intensity and persistence of motivation. Particularly interesting in this regard is the compensatory model of work motivation and volition. The compensatory model of work motivation and volition discusses the conflicts between its structural components: implicit motives, explicit motives, and perceived abilities. It then demonstrates how to resolve conflicts between them through volition and problem solving. This way it combines existing models of motivation. Dual system theories, that discuss the conflicts between implicit and explicit motive systems.(McClelland et al., 1989; Sheldon and Kasser, 1995) Volitional regulations, the mechanisms to resolve those conflicts.(Kuhl, 1985; Sokolowski, 1993) Perceived abilities (Kanfer and Ackerman, 1989; Klein, 1989; Vroom, 1964), which can be compensated for by problem solving. In figure 2.10 there is an overview over the model.

The model addresses the issue of why some goals are not motivating, even when they were set voluntarily. The model focuses on motivating employees in a company, but the results of the model are valuable for games, as one of the major motivational aspects in games is their ability to set appropriate goals.

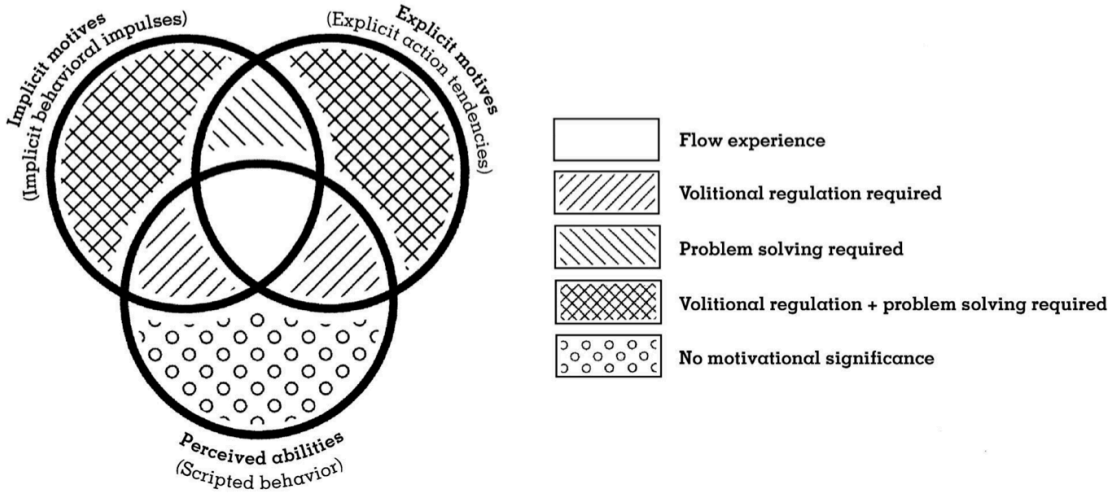

Figure 2.10: Compensatory model of work motivation and volition

In order to understand the model more deeply, it is necessary to regard the

single components of the model and their relation to each other.

Implicit motives subconsciously steer preferences and behavioral impulses.(McClelland, 1985) Common implicit motives are power (exert social control over others), achievement (meet or exceed personal standards of excellence), and affiliation (establish or intensify social relationships). Implicit motives are varied and highly depend on the individual. They can be measured using the Thematic Apperception Test.(Murray, 1943; McClelland, 1985)

Explicit Motives in contrast to implicit motives are the conscious reasons people self-attribute for their actions.(McClelland et al., 1989) They are strongly influenced by social demands and normative pressure.(Koestner et al., 1991; McClelland, 1985) Hence they often stand in conflict with implicit motives. Explicit motives can be assessed using the Personality Research Form.(Jackson, 1984)

Perceived abilities have been identified as an important determent of (work) motivation.(Azjen, 1991; Bandura, 1977; Tubbs and Ekeberg, 1991; Ambrose and Kulik, 1999; Kanfer, 1990) On the one hand having low perceived ability for a specific task reduces the motivation to pursue it. For example it is very hard to motivate oneself for an exam, where one is convinced to fail anyways. On the other hand having high perceived ability will not ensure motivation. While most perceive their ability to vacuum their room as sufficient, they might still not want do it.

Relation between implicit motives, explicit motives, and perceived abilities Implicit and explicit motives, and perceived abilities all influence motivation and behavior. Research shows that implicit motives are particularly influential in determining long-term behavioral trends (e. g. McClelland (1985); Spangler (1992); Heckhausen (1991); Chusmir and Azevedo (1992); Langens (2001); McClelland and Franz (1992); Sokolowski and Kehr (1999)). In contrast, explicit motives influence cognitive choices and goal setting (e.g.,Azjen (1991); Atkinson (1964); Locke et al. (1990); McClelland (1985); Spangler (1992); Tubbs and Ekeberg (1991); von Rosenstiel et al. (2000); Vroom (1964)). Low perceived abilities in general reduce the motivation. However they to not preclude intrinsic motivation, only flow.(Kehr, 2004b)

Interestingly the three components of motivation are conceptually independent determinants of behavior. This means someone can have an explicit motive to study for a test, in order to do well. However implicitly, he is afraid of appearing untalented. Combined with the perception of low abilities in the field of the exam, he cannot motivate himself to study. Avoiding to study, allows him to avoid failure. If he does not pass the test he can now attribute to the lack of preparation, instead of his talents.

The example already shows that there can be massive conflicts between implicit and explicit motives, and perceived ability. Performance and personal well-being

are highest, when all three components are aligned. Conflicts between them can cause intrapersonal conflicts, which do not only result in performance deficits, but may even lead to health problems.(Bazerman et al., 1998; Brunstein et al., 1998; McClelland et al., 1989; Ryan and Deci, 2000b; Sheldon and Elliot, 1999) Of course it is not always possible to avoid conflicts between the three components. In those cases compensatory methods of volition and problem solving need to be applied. Both will be described next in some detail.

Volition is a willful act to either support explicit action tendencies, even though they conflict with implicit motives (Brunstein et al., 1998; Emmons, 1999; Epstein, 1998; Kuhl and Goschke, 1994; Ryan et al., 1996) or to suppress implicit behavioral impulses (Ach, 1910; Bargh and Pietromonaco, 1982; Posner and Snyder, 1975), that are contradictory to explicit motives. "When implicit and explicit motives are congruent, no volitional regulation is required"(Kehr, 2004b).

While volition helps to act in certain ways in the short run, it has its limitations. First of all, it is a depletable resource, that becomes ineffective, if a person needs to apply it all the time. An example for this is keeping up your diet, or doing sports on a regular basis. Second, the need for regulation blocks cognitive capacities. Finally, constantly controlling actions explicitly, can lead to "overcontrol", which in the long run can reduce well-being and lead to alienation.

Problem Solving While volition is the cognitive mechanic to resolve conflicts between implicit and explicit motives, problem solving is required when the perceived ability to achieve a goal is too low. Problem solving is a conscious process used to overcome environmental difficulties. It is required when no behavioral routines exist. A person with lower perceived ability will more often perceive a situation as novel, leading to more frequent interruptions of their behavioral routines ((Lord and Kernan, 1987; Schank and Abelson, 1977; Kanfer and Ackerman, 1989). This interruptions require effort.

Summary The compensatory model of work motivation and volition consists of three components: implicit motives, explicit motives, and perceived ability. If all three are aligned, motivation is highest, and a person can even reach flow. If they are not aligned problem solving or volitional regulation are required. "Actions requiring both problem solving and volitional regulation are likely to be abandoned or lead to failure."(Kehr, 2004a)

Good games usually manage to align all three motivational components. Most games have one or two common implicit motives that they support strongly. This can either be dominating another team or person (Player vs player in League of Legends[1]), power (GTA V[2]), discovery (Legend of Zelda[3]), self-expression

[1]Two teams fight over territory (`http://euw.leagueoflegends.com/`)
[2]Grow your criminal empire with GTA Online. (`http://www.rockstargames.com/V`)
[3]Explore the continent Hyrule (`http://www.zelda.com/`)

(Minecraft[4], Sims[5]), creating (Sim City[6]) achievement (arcade games), social connection (World of Warcraft[7]) etc. This of course means that some kinds of game are motivating to only some very specific players. Furthermore games often set very clear explicit goals for the player. Those goals are usually something, that is important within the game world, like saving the kingdom/world, collecting treasure, or uncovering an important secret.

Finally, games communicate to the player on a subconscious level, that they can achieve the goals set by the game. This helps to increase the perceived ability and avoid motivational barriers due to feelings of being incapable. Games do this, by showing the player very clearly, whenever he made progress. They often split major game goals into small achievements. Every achievement is animated clearly. In cases where players get stuck, many games provide tips to help the player along.

2.3 Social Interaction Definition

Social interactions can be described as "dyadic unit"(Sears, 1951, p. 476-483), where the behavior within the interaction does not only depend on personal characteristics of the participants in the interaction, but also their relation to each other. This means that the structure and environment the interaction surrounding the interaction influences the interaction to a similar extent, that the individuals participating in it.

This means social interactions include direct interactions, like debating with another person or drinking a coffee together, as well as mediated interactions like chatting, exchanging virtual goods, or racing for better scores. Social interactions range from positive interactions (e.g. rewarding someone), over neutral (e.g. paying at the cashier) to negative interactions (e.g. fighting over a scarce resource).

Games provide great opportunities to foster a broad variety of social interaction. This starts with comparing scores and achievements in a leader- board, over social games that allow sending presents, and reaches to multiplayer games that foster collaboration or competition and allow to signal other players, exchange opinions, trade, support or attack other players. In fact many successful computer games include social inter- action as core elements of their gameplay (e. g. League of Legends, Call of Duty, Diablo 3, Mario Kart, FarmVille, ...). The observation that computer games that incorporate social interaction are highly popular is confirmed by Gee who states: "We found that most [students] played video games not alone but with others [...]".Gee (2007)Social interactions are a good learning tool

[4]Build your own world (`https://minecraft.net/`)
[5]Steer the life of your sims (`http://www.thesims3.com/`)
[6]Build a city (`http://www.simcity.com/`)
[7]Go on adventures as a group (`https://worldofwarcraft.com`)

as "the social situation maintains student motivation and naturally elicits verbal communication"(Roschelle and Teasley, 1995).

2.3.1 Collaboration vs. Cooperation

This is particularly true in collaborative environments. Panitz (1999) sees collaboration as "a philosophy of interaction and personal lifestyle" and cooperation as "a structure of interaction designed to facilitate accomplishment of an end product or goal through people working together in groups". He states the cooperation is usually content specific and more closely guided, while collaboration is centered on the learner.

Slavin (2011) associates cooperative learning with well-structured knowledge domains and collaborative learning with ill-structured knowledge domains. Roschelle and Teasley (1995) also make a distinction between collaboration and cooperation. They state that: "Cooperation is accomplished by the division of labor among participants, [...] where each person is responsible for a portion of the problem solving." In contrast they see collaboration as "mutual engagement in a coordinated effort to solve the problem together". This perspective is supported by Lehtinen et al. (1999) who see the distinction based on different ideas of the role and participation of individual members in the activity.

The debate is still going on and it is beyond the scope of this article to state which definition or perspective is most appropriate. It is, however, more important to stress that there are far more similarities than differences between the two Kirschner (2001); Kreijns et al. (2003). Kirschner notes that learning is an active process, that is facilitated by the teacher. In both collaboration and cooperation learners participate in group activities and must take responsibility for their learning. The teacher is not a "sage on the state", but stimulates learners to reflect on their assumptions and thought processes.

Since there are fare more commonalities than differences we consider the two to be equivalent in the rest of this dissertation.

Collaboration can be defined as "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem"(Roschelle and Teasley, 1995). Intuitively, a situation is termed collaborative if peers are more or less at the same level, can perform the same actions, have a common goal and work together(Arnseth et al., 2001), it is usually not applied when for example teacher and student work together. Situations depicted as collaborative are generally rather symmetrical with respect to actions (compared to control, coordination, ...) or expertise (compared to tutoring, teaching, coaching, ...).(Arnseth et al., 2001)

Collaborative learning is not a single mechanism: if one talks about "learning from collaboration", one should also talk about "learning from being

alone"(Dillenbourg, 1999). [Instead] trigger some learning mechanisms (induction, deduction, compilation, ...). [...] This includes the activities/ mechanisms performed individually, since individual cognition is not suppressed in peer interaction. But, in addition, the interaction among subjects generates extra activities (explanation, disagreement, mutual regulation, ...) which trigger extra cognitive mechanisms (knowledge elicitation, internalization, reduced cognitive load, ...) [...] These may occur more frequently in collaborative learning than in individual condition. Because of these multiple interactions, it is very difficult to set up initial conditions, which guarantee the effectiveness of collaborative learning.(Dillenbourg et al., 1995) Nevertheless collaboration can foster learning when those cognitive mechanisms are triggered.

2.3.2 Competition

"Competition is a manifestation of the natural rivalry created when people and organizations clash over common desires. Competition is a dynamic that often produces a distinct feeling of motivation and aggression. A lack of competition can lead to confusion about what it means to win, and a loss of intensity in the activity itself."(Dignan, 2011) Competition can be a motivator, especially in the context of a game, where failing is comparably innocuous. Fullerton (2008) "promote the conflict-script as suitable candidate for scripted collaboration. Such scripts (or didactic scenarios) take conflicts as starting points for learning and discovering multiple aspects and perspectives of a problem. Conflicts can entail physical or mental obstacles, different perspectives, stakeholders and/or ethical dilemmas."(Hummel et al., 2011). Many popular games contain competition (Battlefield, League of Legends, Mario Kart). Chris Crawford sees conflict and safety both as the core for the motivational power of games. However conflict also always implies danger. Therefore, games need to find a way to provide the psychological experience of conflict without bad real-world repercussions.(Crawford, 2003).

2.4 Games

One of the oldest known games is Wei Hai that became popular in China 3000 BC (Griffiths, 2013, p. 7). Games are so prevalent in human civilization that (Huizinga, 2004) even claimed civilization arises from play and is impossible without it. In this chapter we will explore the characteristics of a game and how it can be distinguished from toys and play. We will then dwelve into creating a taxonomy of games to realize how broad the field of games is.

2.4.1 Definition

> *I have tried to avoid the philosophical short-circuit that would assert all human action to be play. Now, at the end of our argument, this point of view awaits us and demands to be taken into account. ... What is play? What is serious?*

(Huizinga, 2004, p. 212-3)

Intuitively people seem to understand what a game is. Monopoly clearly is a game, while doing chores at home is not. Playing soccer is a game, but jogging is not. This is all the more astonishing when looking at the great variety of games, that at first glance, seem to have almost nothing in common. After all, what is it that connects Monopoly and soccer. What are the commonalities between the two?

Hence, while a definition of the term game seems easy at first glance, it might in fact be very difficult due to the variety of games. This is further complicated by the arrival of computer games. There exist a multitude of activities, which most people would label as games without hesitance, that apparently do not have anything in common.

With this in mind we analyze various definitions of the term game.

> [...] Video games are based on two fundamental ingredients: interaction and pleasure (or fun). (Huynh-Kim-Bang et al., 2012)

In addition to interactivity Huynh-Kim-Bang mentions fun as a vital component for games. But if games are generally fun, what elements of games contribute to that joy. In order to find out, we should have a look at the definition proposed by Costikyan.

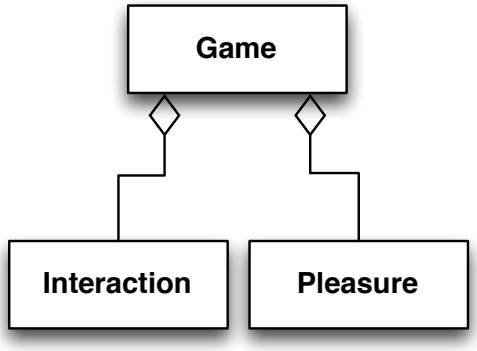

Figure 2.11: Game definition by Huynh (UML class diagram)

> A game is a form of art in which participants, termed players, make decisions in order to manage resources through game tokens in the pursuit of a goal. (Costikyan, 1994, p. 9-33)

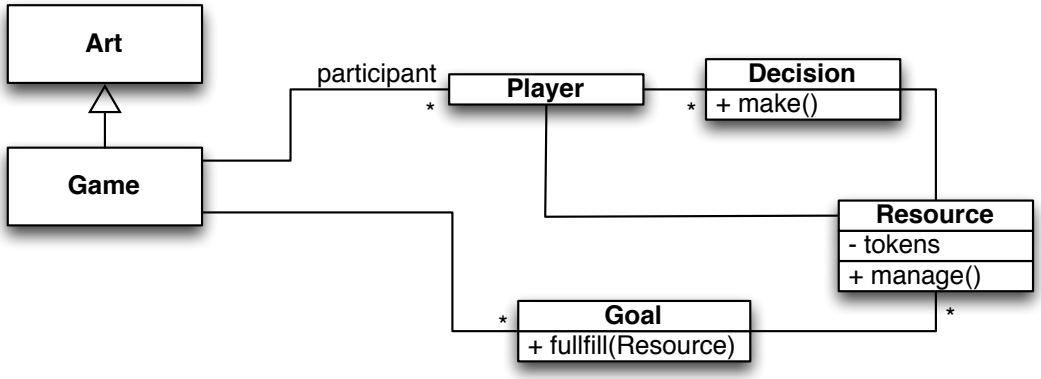

Figure 2.12: Game definition by Costikyan (UML class diagram)

The definition describes several elements of a game that have powerful influences on the experience created. First of all, players pursuit a goal. The goal serves as a strong motivator to play and win the game. Having a goal is not necessarily unique to games, but games do their best to make those goals more appealing. Further analysis shows that the goals in games mostly promise a large impact on the whole game world. More often than not the player is saving the whole world not carrying out the garbage.

Furthermore, unlike in the real world, the player is aware of the fact that the goal is certainly reachable. Games usually break down the global goal into smaller more approachable and concrete side quests. All of this taken together leads to SMART goals (**S**pecific, **M**easurable, **A**ttainable, **R**esults-based, and **T**ime-bound) (Wade, 2013), which have been shown to be highly effective in and out of games. Clear goals are directly motivating - they enable people to plan, carry out instrumental actions, and feel proud when the goal has been accomplished.(Bandura, 1994)

Second in order to manage resources, players make decisions. Those decisions usually heavily influence the course of the game. This makes them meaningful, which evokes a feeling of impact and effectiveness in the player, further strengthening motivation. Mark Prensky agrees that "decisions typically affect the course of the game."(Prensky, 2000, p. 150)

Finally, the definition refers to resources, which are a means to reach the goal. Games achieve interesting game play by limiting the resources, making it exciting to obtain or fight over them.

In fact Salen and Zimmerman (2003) describe artificial conflicts as a crucial component of games.

> A game is a system, in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome." (Salen and Zimmerman, 2003)

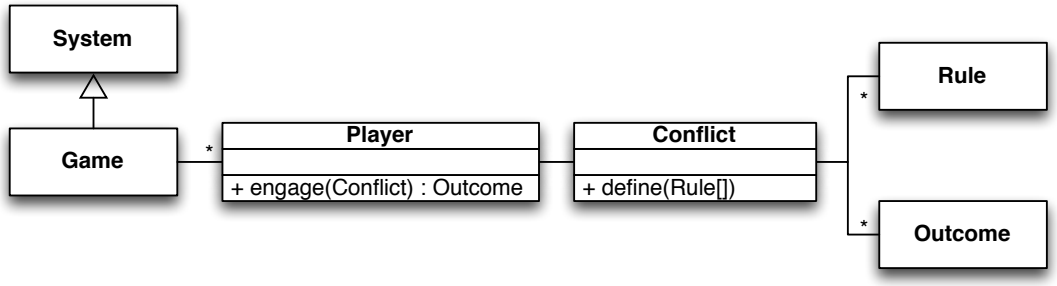

Figure 2.13: Game definition by Zimmermann (UML class diagram)

Fullerton (2008) has a similar depiction.

> Games are closed, formal systems that engage players in structured conflicts which resolve their uncertainty in an unequal outcome. (Fullerton, 2008)

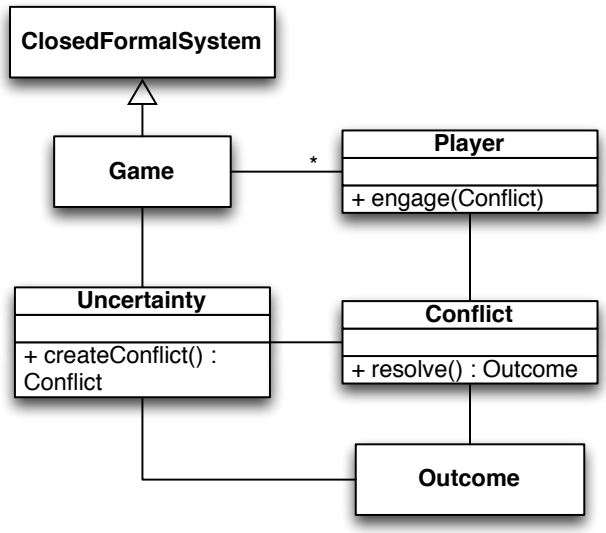

Figure 2.14: Game definition by Fullerton (UML class diagram)

The definitions of Salen, Zimmermann and Fullerton see conflicts as a core part of games. While conflict for many humans has a negative connotation, games structure those conflicts through rules. As all players of the game agree to the rules before they start to play, the conflict is tamed and thus does not escalate. Instead it becomes highly exciting to play through the conflict and experiment with the consequences that each decision yields on the outcome. Hence the conflict creates a pleasant tension between the players, which can be influenced by their decisions and interactions throughout the game, when it is finally resolved into an outcome that signals the end of the game.

This tension is especially interesting as even in games where every player starts off in the exactly same situation the outcomes are highly uncertain and unequal and strongly correlate with the decisions made by every player. In fact many players spend a lot of time on meta gaming. This is a process where players discuss their strategies and decisions within the game and hypothesis on their effect of the outcome.

Interestingly, while players tremendously thrive on uncertainty when playing games, studies in psychology show that usually uncertainty can be a stressor. While the amount of control games provide over the uncertainty certainly reduces the stress level, it still is not enough to explain, why players can enjoy the uncertainty within games to the extent they do.

The definition of Caillois can shed some light on this.

> A game is an activity that players choose freely for its joyous qualities and because it is limited in time and place, which separates it from the real world. Its outcome is uncertain and the activity is non-productive. Games are governed by rules and accompanied by make-belief.(Caillois, 2001, p. 9-10)

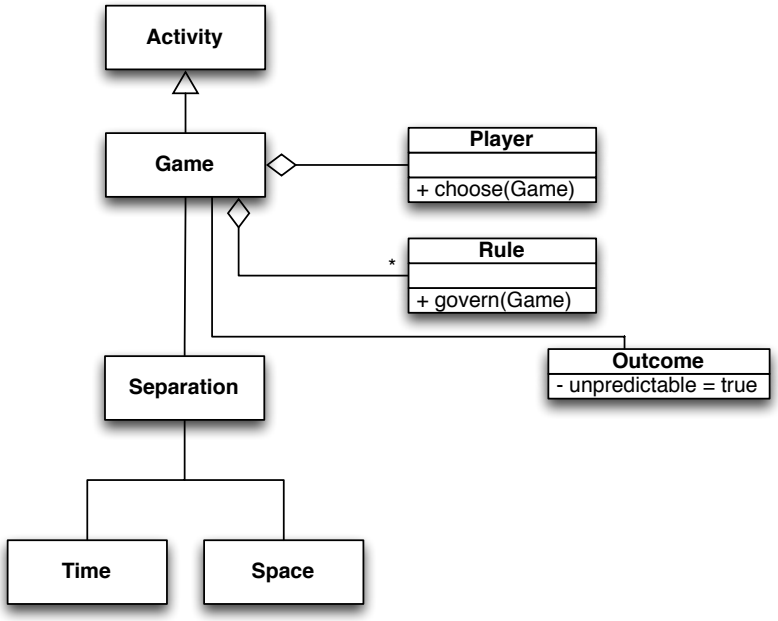

Figure 2.15: Game definition by Callois (UML class diagram)

The definition emphasizes that the established rules separate the game from ordinary life, not only in time and space, but in its consequences. For the players this means, they can safely experiment with strategies, behaviors, or ideas, that might be considered reckless outside of the context of the game. This safe haven is also referred to as the magic circle based on the observations made by Huizinga in Homo Ludens.

> The arena, the card-table, the magic circle, the temple, the stage, the screen, the tennis court, the court of justice, etc., are all in form and function play-grounds, i.e. forbidden spots, isolated, hedged round, hallowed, within which special rules obtain. All are temporary worlds within the ordinary world, dedicated to the performance of an act apart.(Huizinga, 2004)

Rules establish the boundaries of the magic circle. The players find themselves in a separate world that is typically much simpler than the real world. The illusion is often framed by a fantasy context that explains why the rules are so simple. This is why many games either play in the past, an apocalyptic future, or worlds with evil demons.

With this last step we are now can attempt a definition of the term game, that gives new designers some ideas on how to make their games more exciting.

Games are **interactive experiences** that take place within a **magic circle**, which separates players from the real world and its consequences, established by rules and fantasy. Games provide players with **autonomy** by allowing them to make decisions that influence the outcome of the game. This evokes **emotions**, e. g. tension, curiosity, relatedness and fun.

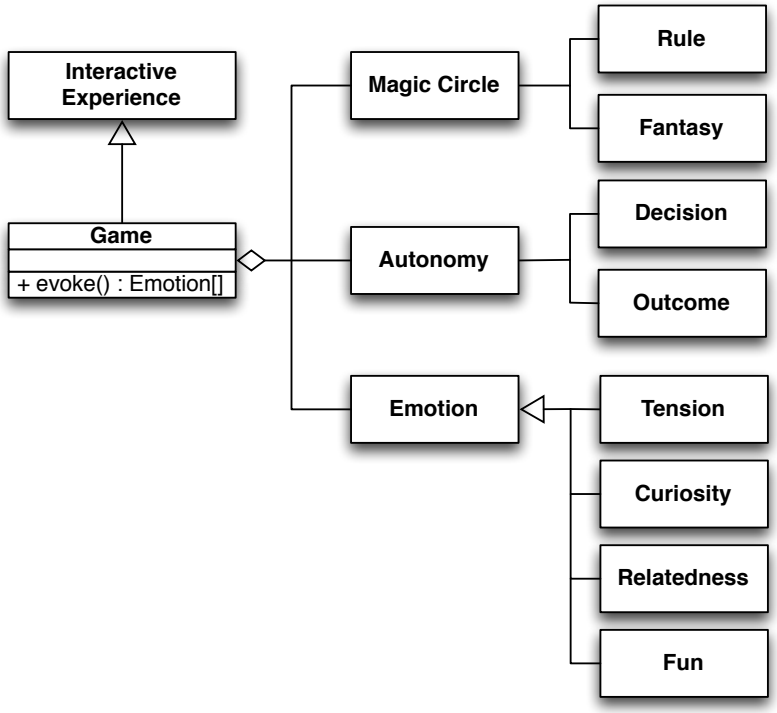

Figure 2.16: Game definition used in this dissertation

2.4.2 Game Taxonomy

A good taxonomy allows for the classification of games into categories. The categories should be mutually exclusive and suggest areas of design(Crawford, 2003, loc 528-529). Ideally they even help to find out, which kind of game design is suitable for a particular purpose.

(Caillois, 1963, p. 148) developed a macro-taxonomy, which "proposes very broad categories that seek to cover the entire human range of play". He suggests that games consist of a gameplay aspect and style. He distinguishes four different aspects: competition (agon), chance (alea), simulation (mimicry), and vertigo (ilinx). He suggests that there are two opposing styles: spontaneous free play (paida), and conventional structured play (ludus).

This taxonomy is very interesting in that it allows for broad categories, that can fit all games. However the four different aspects do not appear to be mutually exclusive. The game, dungeons and dragons for example, lays importance on building your character that simulates a real person within the game universe. Additionally for every action, like fighting enemies or opening locked doors, the player has to do a skill-roll. This means dependent on the character skill he gets a certain amount of dice and has to roll a number higher than the set threshold to succeed. While the first part of the game fits into the category of simulation, the second part fits into that of chance.

Also the categories are so broad that two games in the same category still are very dissimilar. Snakes and ladders, roulette, and black jack all can be considered games of chance, but they are vastly different. Snakes and ladders is a board game, while black jack is played with cards. Roulette players gamble with real money, while such an idea seems absurd for snakes and ladders. Black jack does not solely depend on luck as players can use their knowledge of statistics to make decisions, which increase their chance of winning.

The taxonomy is still not entirely without value. It gives some hints on why players play and what they would want to play. Competition to demonstrate once skill to other players; Chance to be surprised; Simulation or mimicry to see the world from a different perspective or live a power fantasy (god games); Vertigo to arouse strong emotions and separate from reality.

In general the taxonomy suggested by Roger Caillois is too broad and vague. It also does not do justice to computer games, which allow for some new forms of play not formerly possible. Hence we look at the taxonomy of Chris Crawford who is one of the early pioneers in computer game design.

Crawford distinguishes two fundamentally different groups of games: skill-and-action and strategy. He argues that skill-and-action games primarily demand hand-eye coordination and fast reaction time. On the other hand strategy games focus on cognitive effort. Within both groups he identifies several subcategories.

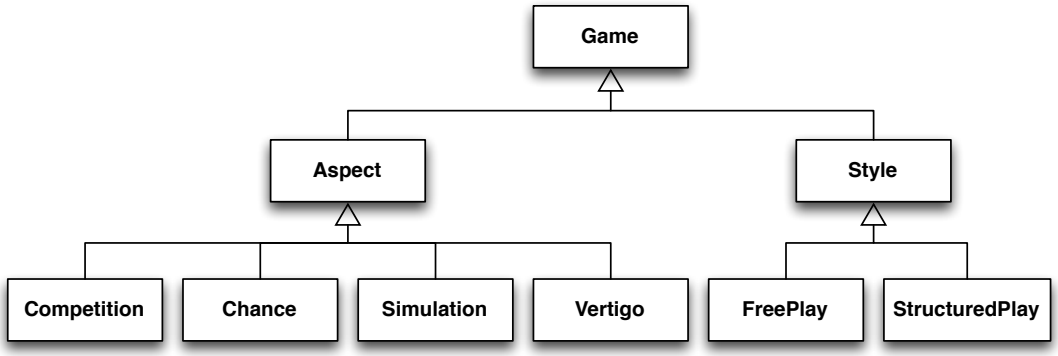

Figure 2.17: Game taxonomy by Caillois (1963, p. 148)

He categorizes Skill-and-Action games into combat, maze, sports, paddle, race, and miscellaneous; he categorizes strategy games into adventure, DD games, wargames, games of chance, educational games, and interpersonal games.

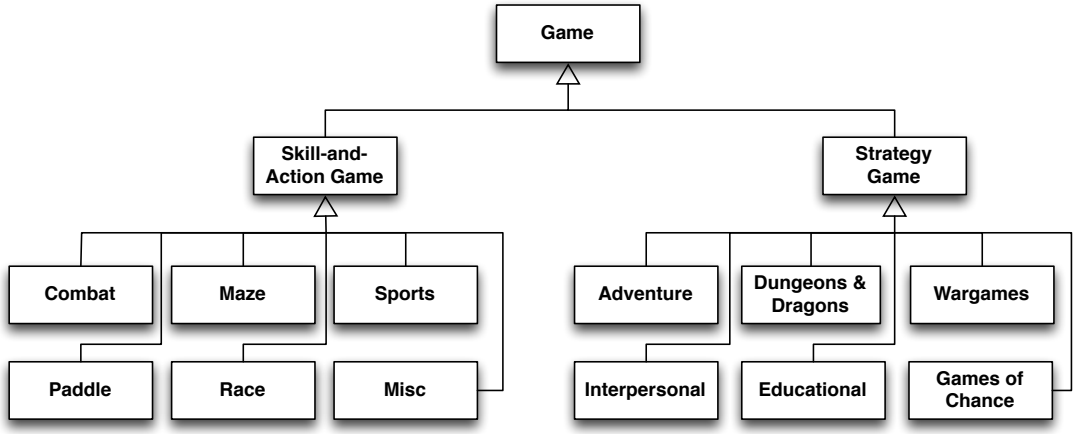

Figure 2.18: Game taxonomy by game designer Crawford (2003, loc 532-651)

This categorization is shaped by the types of computer games that existed at the time. The categories are more detailed than those by Caillois and thus give more concrete ideas for design. But they are on very different levels of abstraction. While combat games are a group of games characterized through a set of common gameplay elements like complex control scheme, ability to jump, kick, box, and block, limitation to an arena, selection of different characters, sports games are defined solely by their underlying theme; Paddle games are defined through the occurrence of the player character and maze games through the game space. Similarly

strategy games are divided by purpose (educational), social interaction (interpersonal), or theme (wargame). While all of those things are important characteristics of games, they do not fit together.

For example there are combat games that play in a maze. Games like a sport manager are not based on skill-and-action. Also real-time strategy games, which were not possible at the time, cannot be placed within this taxonomy. While the taxonomy contributes different design ideas it mixes various aspects like theme, game space, core mechanic, and interaction with other players. Also it still omits a lot of genres of games that have developed after the book has been written. Crawford himself even addresses the problem of his taxonomy when he says "The field is too young, the sample too small, for whatever organizing principles there may be to have asserted themselves. The games we now have are more the product of happenstance than the inevitable result of well-established forces." (Crawford, 2003, loc 528-529)

Bates (2004, p. 6-12) classifies games into several genres: adventure games, action games, role-playing games, strategy games, simulations, sports games, fighting games, casual games, god games, educational games, puzzle games, and online games.

In comparison to the taxonomy of Crawford, new genres are: casual games, god games, puzzle games, and online games. The taxonomy only has one level of hierarchy. On this level several aspects are mixed together. The underlying technology (online game), theme (sports game), difficulty (casual game), purpose (god game), mechanic (adventure game, puzzle game, god game, fighting game, simulation), and interaction mode (action game).

The taxonomies studied so far are either inconsistent (a game can be placed in several categories), incomplete (some games do not fit any category), have too broad categories (very dissimilar games still are put into the same category), or mix several aspects (theme and purpose are considered on the same level).

Hence in this dissertation we use a taxonomy based on five dimensions: theme, core mechanic, social interaction, interaction style, and success criteria. Each dimension has its own significant impact on the resulting game. Of course there are far more dimensions, which could be used to classify, but those dimensions have the largest impact on the look and feel of a game and hence the target group interested in playing the game.

Let us have a look at each of the dimensions suggested and how they affect the target group of the game.

Theme: The theme is often the first thing players perceive from a game, as - unlike the other dimensions - it is visible directly from screenshots. The variety of themes is staggering, and we only want to show a few examples. There are games placed in space, the future (science fiction), epic fantasy worlds, war, sports, games

about being a thief, god, celebrity. The theme sets the tone of the game. There are many games that play extremely similar, e.g. Age of Wonders III and Civilization IV, due to the theme they appeal to very different player groups. There are players that only pick up games with their favorite theme.Picking the theme is therefore very important even though the underlying implementation would still look precisely the same.

Core Mechanic: Game mechanics are "the actions or methods of play allowed by the rules [...] they guide player behavior, creating interactions".(Fullerton, 2008, p. 29) Some mechanics are tied to specific themes. For example epic fantasies are very often coupled with role-playing mechanics, where the player creates a personalized character and develops it through decisions made in the game. Sports games are often either management games or games on running and action. Almost all stealth games involve being a spy or thief. However this coupling while common is not necessary. The core mechanic has a major influence on how it feels to play a game. Mechanics like shooting, running, or fighting usually feel hectic and action-loaded. Mechanics based around management of resources, solving puzzles, or stealth, usually feel slower and focus more on thinking. The decision for a specific core mechanic often also informs the decision of the interaction style.

Social Interaction: Some games are pure single player games, that do not have any social interactions. But some games are built around social interactions between players. The games are either collaborative, where players work together to achieve a goal, or competitive, where everyone tries to win against his opponents. Lastly, there are also games that contain both collaboration and competition. Those social interactions can either happen locally or via network.

Interaction Style: Interaction between player and game can be categorized as either realtime or turn-based. In realtime games the player can act continuously, meanwhile the opponents also act independently from him. Examples are games like Super Mario World or Star Craft. In turn-based games, the player and his opponent take discrete turns. While it is one players turn, the other players cannot take action. This is similar to most board games. Games like Heroes of Might and Magic or Puzzle Quest fit into this category. Some games mix real-time and turn-based game play. For example in Lara Croft Go the player still moves in discrete steps, but every time he moves, the player moves one step simultaneously. In the shooter Super Hot, the player moves continuously, but his opponents can only move when he is moving and only at the same rate as he is moving. **Success Criteria:** Games can either be won by luck or skill. Games like chess, checkers, need for speed, or super mario world for example are entirely based on skill. There is no luck involved at all. On the other hand games like snakes and ladders or roulette are almost entirely based on luck. Inbetween there are games like settlers of catan, civilization, mario kart, or candy crush. Those

games occasionally randomize events, but still give room for the player to win the game through skill. This dimension has large ramifications for the players. Usually games that involve luck appeal more to casual players, while games that involve skill appeal more to hardcore players. There are two reasons for that. First imagine, really good player of racing games and really competitive. In a game like mario kart, which involves luck, it could happen, that a really bad player picks up a blue shell, and hits you with it. The blueshell is an item that always hits the player in first place, and there is no way to avoid it. Hence after getting lucky and picking up the item, there is no skill involved at all. So in Mario Kart if a player is on first place and hit by a blue shell, he might be thrown back several ranks, even though she made no mistake at all. For the proficient player this feels frustrating and unfair. In comparison, for a casual player it can feel exhilarating, as he still has some chance to compete and win against experienced players.

In contrast a game like Need for Speed does not involve luck. Therefore the winner is determined only by skill. For experienced players that feels more fair and allows them to determine their actual skill in comparison to other players objectively. Their highest scores are not or only minimally colluded by luck. On the other hand for casual players, a game like that can seem daunting and frustrating, as they simply have no chance to compete against the scores of more experienced players.

A game based on luck has a different target group than a game based on skill. Luck based games appeal to casual players, while skill based games appeal to hardcore players.

2.5 Serious Games

The term Serious Game was first introduced by Clark C. Abt in 1970:

> We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining. (Abt, 1970, p. 9)

While his definition refers to board games and not to digital games, it already contains most of the attributes that are central to current serious game definitions. Abt states that the primary goal of a serious game is not entertainment but education. The same stance towards serious games is taken in several newer definitions. The only major difference lies in the fact that newer definitions restrict themselves to digital games.

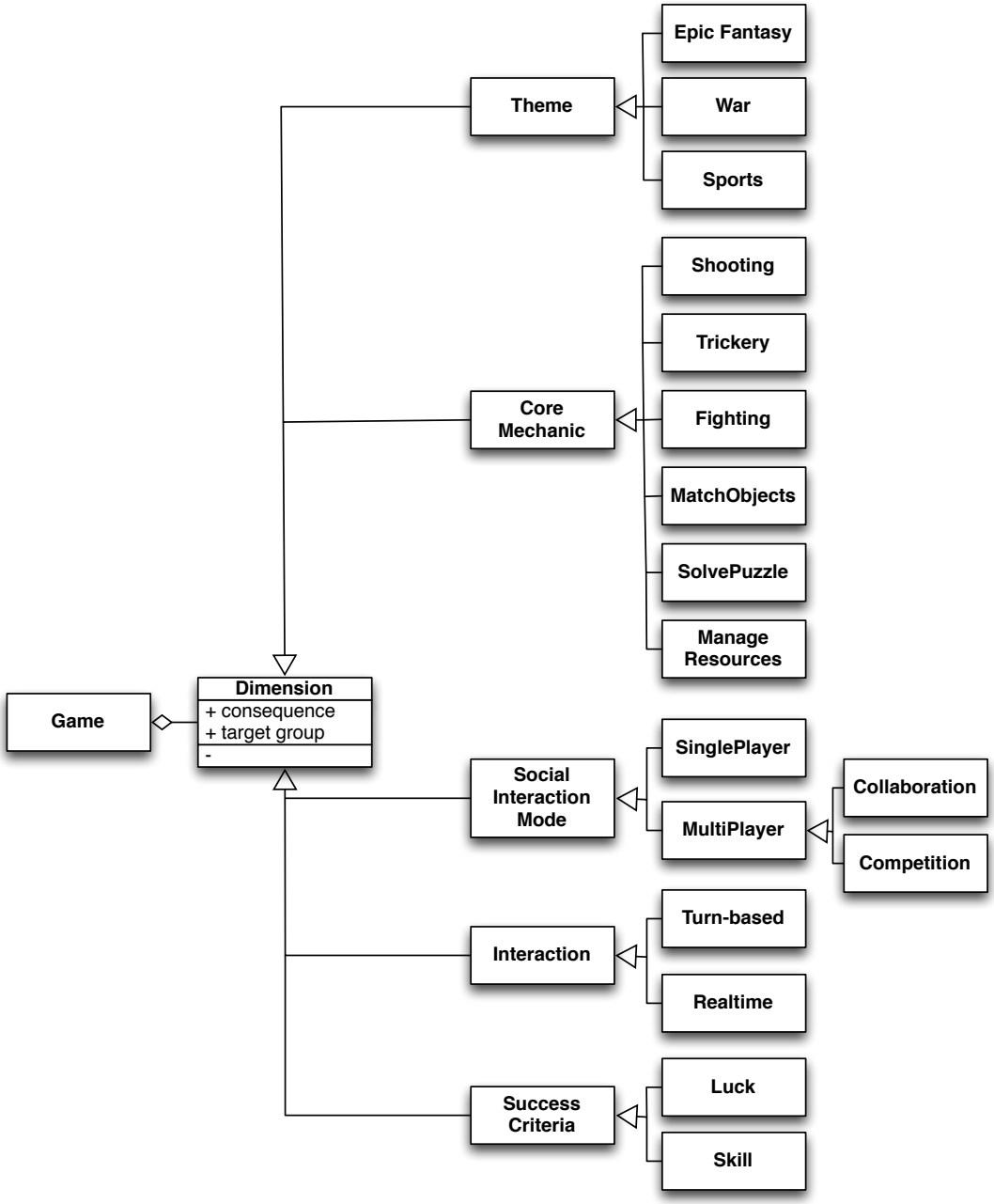

Figure 2.19: Taxonomy by Game Dimensions

> Serious games have more than just story, art, and software, however. [...] They involve pedagogy: activities that educate or instruct, thereby imparting knowledge or skill. This addition makes games serious. Zyda (2005)

> A serious game is a game in which education (in its various forms) is the primary goal rather than entertainment (Michael and Chen, 2005, p. 17)

These definitions see serious games as an extension of games, incorporating educational elements. Bergeron tried to add more detail to this definition, he writes:

> "[...] a serious game is an interactive computer application, with or without a significant hardware component, that: has a challenging goal, is fun to play and/or engaging, incorporates some concept of scoring, and imparts to the user a skill, knowledge, or attitude that can be applied in the real world." (Bergeron, 2006, p. xvii)

He extends the definition by including scoring and goals as indispensable for serious games. While these additional defining characteristics appear helpful at first glance, they restrict the definition unnecessarily. Nevertheless, Bergeron's definition makes some interesting points. He mentions that the serious game should be "fun to play and/or engaging". This ties back with Abt's sentiment that serious games can – and even should – be entertaining.(Abt, 1970, p. 9) The power to motivate and engage is a major reason to develop serious games in the first place. This point is particularly emphasized in the following definition:

> Serious games are "all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as to develop new knowledge and skills". (Corti, 2006, p. 1)

While the definitions so far seem to line up well, (Ulicsak, 2010, p. 27) observes that "within the research community there is no fixed definition of a serious game." However he claims that the

> majority view serious games as: having a learning model embedded, the content is integrated into the game, so learning is intrinsic to play, and the assessment of learning may be integral to the game or occur through mediation around the game. (Ulicsak, 2010, p. 27)

While education might be one of the major goals in many serious games, the definitions presented so far exclude a vast variety of games that are also considered to be serious games by their developers and the majority of the serious games community. For example the game Darfur is Dying[8] is a game, which raises awareness for the genocide in Darfur that has cost the lives of 400.000 people. While the games could be considered to have an educational purpose, namely to teach people about the events in Darfur, its actual goal is to invoke feelings of despair when leading the camp and in turn create sympathy for refugees.

The game 'America's Army' also does not directly fall into the definition of a game with educational purpose. Its goal is advertisement and recruitment for the military.

This observations lead us to a more inclusive definition of serious games, more common by now:

> [...] serious games are (digital) games used for purpose other than mere entertainment.

The definition considers every game a serious game, as long as it has another purpose other than mere entertainment. Tarja then starts to list several widespread areas of application of serious games.

> Serious games usually refer to games used for training, advertising, simulation, or education that are designed to run on personal computers or video game consoles. Tarja et al. (2007)

This list already gives us a better impression on just how broadly the idea of serious games is applied. However the list is by no means conclusive. In fact the following definitions already suggest other sets of application areas.

[8] Online game Darfur is dying (http://www.darfurisdying.com/)

> The "serious" adjective is generally prepended to refer to products used by industries like defense, education, scientific exploration, health care, emergency management, city planning, engineering, religion, and politics.Wikipedia (2017)

> [A serious game is] 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. Zyda (2005)

At this point we have gained a deeper understanding of serious games already. However so far we have modeled the seriousness of a game as a binary property that is either developed into the game or not. Isabelle Avers refutes this point, when she writes:

> Serious Games are games, which are **used in a pedagogical way for political, social, marketing, economical, environmental or humanitarian purposes.**(Arvers, 2009)

For Arvers, any game can be considered a serious game, when the game is played in a context that serves a specified higher goal. For example the entertainment game "Minecraft" has found a broad community of teachers applying it to teach all sorts of topic, like geography, mathematics, language and science. None of those applications were integrated within the original game, but are established through modding or the context the game is played in.

One definition explicitly mentions that existing games can become serious games through the context in which they are used:

> [Serious games are] adaptation[s] of existing, or the design of new, engaging games that monitor and support students' learning of academically relevant skills.(Shute et al., 2009)

"An open question concerning these purposes is to what extent they need to be socially desirable to label a game serious. As we will discuss in the further thrust of the paper, there are e.g. serious games that have political contents. If we just take the formal game structure into account, games that contain extremist propaganda

would also be serious games as they do want to inform or educate (or in this case rather indoctrinate) their players.(Swertz, 2009) Since the normative evaluation of educational contents strongly depends on who uses them and in what context they are employed, the question of the acceptability of subjects and ideologies cannot be dealt with in a definition of serious games. This means that the label serious games is not equivalent to socially desirable effects on the player."(Breuer and Bente, 2010)

2.6 Patterns

The idea of patterns originates from the work of Alexander (1987), who used them to describe typical situations in building and city architecture. He writes: "A pattern is a recurring solution to a common problem. It captures the experience of experts in a structured way." The idea of patterns was applied to programming by Beck and Cunningham (1987). In 1994 design patterns became popular with the book "Design Patterns: Elements of Reusable Object-Oriented Software"(Gamma et al., 2005). Since then patterns have been applied to a wide variety of fields, including education and game design.

2.6.1 Pattern elicitation methodology

There are two main approaches to pattern identification: deductive or inductive pattern elicitation.(Baggetun et al., 2004)

Deductive pattern elicitation begins with general views and moves toward specific ones. The starting point here form general experiences. The goal is to identify reoccurring problems and then based on theories (e.g. learning theories) try to extract patterns. The patterns by Alexander (1987) have been created this way.

Inductive pattern elicitation begins with specific views and moves toward general ones. The starting point with inductive methods are examples or observations. Patterns are then extracted by asking questions with the goal to pinpoint the reason for success, e.g. "Why is this specific solution good or bad in this situation?" "Is this transferable to other situations?" "What forces contribute to the solution?" The design patterns by Gamma et al. (2005) have been developed this way. They documented and collected existing solutions that have been applied multiple times and are running in different systems.(Gamma et al., 2005, p. 2)

2.6.2 Related Patterns Languages, Libraries, and Frameworks

In this chapter we give a brief overview over existing pattern languages that are related to serious games. The three most relevant domains are pattern languages on serious game, games and education.

There already exist several pattern languages, libraries, and frameworks on serious game design. All of them take slightly different approaches in their attempt to meld pedagogical and game play aspects.

Quinn (2007) **extended the design cycle** of software projects. For each step - Analysis, Specification, Implementation, and Evaluation - he identified additional questions and steps that are specific to the development of engaging simulations for teaching.

In analysis this means gathering information on objectives of the simulation, information about the audience, and clear goal metrics on how the simulation will be rated. During the specification process, the designer needs to settle on a setting and how learners will be evaluated, during play or in a separate summative assessment. For implementation, Quinn suggests three different forms for the final implementation with increasing learning value and fidelity. On the lowest level he sees multiple-choice questions, then branching scenarios, where decisions have wider implications and lastly a game built on a model of the world that simulated decisions. In the evaluation phase he adds the step of evaluating learning outcomes. The order should be testing usability, then learning outcomes and lastly engagement.

The **Game Object Model** by Amory and Seagram (Amory and Seagram, 2004; Amory, 2001, 2007) attempts to create a dialectic between pedagogical dimensions and game elements mainly through design patterns that incorporate the learning content within a story.

Another approach focuses on generation of flow and reflection within problem-based gaming(Kiili, 2005, 2007). It contains similar ideas as the previous model, but introduces the cognitive load theory as an important design factor in serious games.

The Six Facets of Serious Games Marne (2007); Marne et al. (2012) form a well-rounded design library, which concentrates on bringing together ludic and pedagogical dimensions.

The model provides a basis for evaluating and designing educational games. It is based on three pedagogical theories: Keller's Attention, Relevance, Confidence, and Satisfaction/ Success model, Gagné's Events of Instruction, and Piaget's ideas on schema.

The **design, play, and experience framework** (Winn, 2008) was created as an expansion of the mechanics, dynamics, and aesthetics framework(LeBlanc,

2005). It keeps the core idea of the mechanics, dynamics, and aesthetics framework that play is a mediated experience, influenced by cognitive, social, cultural, and experiential background of the player. Hence a designer should work backward from intended goals to create a design, then improve on it iteratively through testing with the target audience.

The framework adds one layer for each sub-component of serious games: Learning, storytelling, gameplay, and user experience. For each layer it provides hints on how to approach its design. The authors also clearly state that the different layers are interconnected and influence each other.

The framework provides an overview over what makes designing a serious game complex. It also provides some ways to analyze existing serious games as well as a starting point to get some ideas to design own games. However it does not make any concrete suggestions on how existing designs could be improved.

In their **Blue Print for Fun and Learning** (Huynh-Kim-Bang et al., 2012) suggest patterns that solve general problems in serious game design. For example some patterns address how to initiate the reflexive process. Other make suggestions on how to convey information without disturbing game immersion. The patterns developed by inspecting 20 different serious games and extracting commonalities.

Sherry, J. L., & Pacheco (2010) argue that serious games for learning are most effective when a games game play matches the desired learning outcome. Therefore they link genre specific learning tasks with Bloom's taxonomy. While not written as clear patterns, they summarize some of those matches and why and how they can be successful.

For example, for the learning of skills, Prensky proposes the use of "imitation, feedback coaching, continuous practice, and increasing challenge" for learning activities, and "role-play games, adventure games, and detective games" as potential game styles.

Kelle et al. (2011) match the game patterns of Björk and Holopainen (2005) to learning functions (e. g. learner regulation or knowledge manipulation). The goal is to reduce design effort required in creating learning games with a balance between game elements and learning. The matching was done by experts and provides information on how well the pattern fit and how much it conflicts with other patterns. Unfortunately, while interesting the approach is currently not useful to beginners in the field.

This lies in the fact that the matchings and the number of conflicts are provided, but no explanation on why and how the patterns could map or which patterns actually conflict. This leaves a lot of room for uncertainty and interpretation, which makes it difficult for beginners to use the given information.

The Games for Learning Institute identified eleven **Educational Game Design Pattern Candidates**. Each pattern candidate is described in some detail

with categories like games, theoretical foundation, references, empirical evidence, informal interview, and example screen shots. The patterns candidates definitely raise some interesting points, but are mere starting points, which is also evident in them being described as "candidates".

In order to improve game design and make it systematic, well-known game designers have developed game patterns. Schell (2008) illuminates different aspects of game design using lenses. The lenses consist of a short description of their context and a set of design questions that are meant to trigger reflection and creativity in a game designer. Lenses 36 to 38 in particular deal with competition and cooperation.

Björk et al. (2003) suggest a set of game design patterns, including patterns on how to foster collaboration and competition (mutual goal, shared reward, trading, balancing effect), while others hint towards forces that complicate the creation of multi-player experiences (Perceived Chance to Succeed, Analysis Paralysis).

In a collaborative effort educational patterns were collected in the **pedagogical patterns project**.(Bergin and Eckstein, 2012) Those patterns cover techniques to introduce a new topic, to deal with dependencies between topics, or figuring out how to evaluate understanding of a topic. The pedagogical patterns project entirely focuses on the context of classroom learning.

The **ROME model**[9] is a process model developed based on principles from pedagogy, informatics, and design. In addition to describing development steps the model elaborates on the creation of contents, methods, and learning materials. While not providing concrete solutions it provides a set of important milestones and questions when developing e-learning materials.(Hambach, 2008)

Bloom's taxonomy distinguishes several stages of learning: evaluation, synthesis, analysis, application, comprehension, and knowledge. The taxonomy is hierarchical, ordered in terms of increasing complexity. "Bloom's taxonomy has been widely accepted throughout the educational system."(Blunt, 2006, p. 26) While the taxonomy does not directly provide any patterns on how to approach teaching, it links every stage with a set of verbs that indicate specific activities especially suitable for each stage in the learning process.

While the patterns reviewed in this chapter address ways to improve learning or playing, only few patterns address how to integrate both. Especially the aspect of social interaction that can be used to make a game more personally meaningful is often not considered. However psychology and pedagogy suggest that personal meaningfulness plays a tremendous role in learning and motivation. Incorporating multi-player elements into serious games is a big opportunity.

[9]Rostocker Modell zur systematischen Entwicklung modularer E-Learning-Angebote

Chapter 3

Serious Game Patterns

Research now needs to focus on explaining why games are engaging and effective and, there is a need for practical guidance regarding how (when, with whom, and under what conditions) to integrate games and learning processes to maximize their learning potential.

TarjaTarja et al. (2007)

In section 3.1 we describe problems that currently exist in serious game development. Section 3.2 states which of those problems could be alleviated by patterns. In section 3.3 we describe the schema for the patterns used in this dissertation. In 3.4 we describe the methodology used to develop the patterns in this dissertation. In section 3.5 we then describe the patterns that can be used to employ social interaction in serious games to improve learning outcomes, replay value and motivation.

3.1 Introduction

"So far serious games have mainly been used to support the practice of factual information."(Kiili, 2005) Many of them focus on mere skill-and-drill mechanics. In doing so, many advantages of using games as learning tools are lost as games are particularly well suited to convey higher-order knowledge.

While there currently exist some serious games that support experimentation, reflection, and foster deep learning in other ways, it is hard to follow their success, due to a lack of knowledge and design ideas. In order to improve this situation, design patterns can be a helpful tool, as they can provide a quick reference, which allows beginners to get a grasp of the complexity of designing a serious game, and for experienced designers, to find new ideas on how to improve their design.(Reichart and Bruegge, 2014)

"Good digital game-based learning does not favor either engagement or learn-

ing, but strives to keep them both at a high level"(Prensky, 2000, p. 150) However achieving this is quite difficult. When we surveyed 136 pupils from ages 12 to 16 only 20% could name a serious game for learning they liked.

This problem stems from two major sources:

First of all, the development team for a serious game has to be diverse. It usually includes educators, game designers, developers, and artists. All of them have different views and approaches to developing a game. In particular conflicts between educator and game designer are preprogrammed, as the educator strives to depict content as realistically as possible, while the game designer wants to create elegant game mechanics, which might require him to cut content.

Second, many serious games for learning try to target every pupil in a class room. This is problematic, as this group is quite diverse. Some have a lot of experience with computer games, while others only play occasionally or not at all. Some like fantasy and others love science fiction themes. Additionally there are differences in familiarity with the learning content. As a result, it is nearly impossible to design a game, that fits all pupils in one class room. However, there are a few patterns that can at least help in balancing the challenge for pupils that perform well and pupils that do not perform so well.

3.2 Goal

Serious Game Patterns help to alleviate some problems concerning the development of serious games. They can establish a basis of communication between different team members. Furthermore, they can help to recognize some problems specific to serious games that might otherwise have been overlooked. Finally, they provide inspiration during development of the game. They can do so during the starting phase and as a means to improve an existing design.

The patterns described in this chapter supplement existing game patterns and serious game design patterns. In particular they emphasize the importance of making the serious game more personally meaningful by including social interactions.

The main target group for the patterns presented in this dissertation are educators and game designers that are new to designing serious games. The patterns provide practical sample solutions to integrate social interaction in serious games.

3.3 Serious Game Pattern Schema

In order to make the navigation easier all patterns use the same structure. The schema here is based on the schema suggested by Alexander (1987) and extended by the suggestions of Wellhausen and Fießer (2011). We also added examples, as

we feel they are necessary to understand a pattern thoroughly.

1. Pattern Name: A name to reference the pattern
2. Context: The circumstances in which the problem is being solved
3. Problem: explains the problem the pattern attempts to solve.
4. Forces: explains why the problem is difficult to solve
5. Solution: explains the solution
6. Consequences: gives an overview over benefits and liabilities of applying the pattern
7. Examples: describes uses of the pattern in existing games and serious games

In order to help understand the pattern schema, we use road work signs. In the rest of the dissertation, we will keep the traffic signs, to make the patterns easy to scan.

This is the context. It describes the circumstances in which the problem is being solved.

Next follows the problem. It is written in a bold font to help your eye navigate to it quickly.

The problem is influenced by forces, which make it hard to solve. In general those forces make it impossible to find an ideal solution for every part of the problem. Here they are often written as a list. The forces sections is concluded with three diamonds.

Next follows the suggested solution to the problem with its forces. It starts with the keyword "Therefore" followed by the solution text.

Further details on benefits and liabilities of the suggested solution help to find out whether the solution is applicable in a particular situation.

The last section describes examples for the pattern.

3.4 Methodology

The patterns in this dissertation were mined from two major sources:

- Existing serious games selected according to criteria like awards, popularity, diversity and accessibility. This approach is comparable to that of Huynh-Kim-Bang et al. (2012).

- Related Pattern Catalogues from game design and educational design. These catalogues already provide a variety of patterns. Those patterns sometimes do not directly translate to the situation in serious games and lack examples on how they could be implemented. Some of the patterns suggested build on existing patterns and adapt them to requirements specific for serious games.

Deductive methods like literature research in the areas of education and game design were used to add more detail to each pattern. Often effective methods of teaching directly follow out of models on learning and motivation. However especially to beginners those conclusions are not easy to make, as they lack overview and insight in those topics. The patterns based on this research want to make the results of those models more directly usable to beginners.

While existing catalogues focus on general game design issues, the patterns presented in this chapter focus on integrating learning content and social interactions in serious games. Because this topic is currently underutilized in serious games.

3.5 Social Interaction Serious Game Patterns

In this section we describe patterns that integrate social interactions into serious games. In subsection 3.5.1 we describe the role social interactions play in learning and why they are useful for improving serious games. In subsection 3.5.2 we give an overview over the patterns. In subsection 3.5.3 we focus on incorporating social interactions into serious games. Next we describe competition patterns in 3.5.4. Lastly, we show how competition and collaboration can be combined in subsection 3.5.5.

3.5.1 Social Interactions in Serious Games

A hypothesis of this dissertation is that integrating social interactions at the core of a serious game however can enhance a serious game. This belief is rooted in Vygotskys social development theory, which argues that social interaction precedes development; consciousness and cognition are the end product of socialization and social behavior. Social interaction is [even] seen as a necessary condition for learning mathematics (Freudenthal, 1991; Treffers, 1986), so Vygotskys observations are not limited to social and language skills, but also apply to abstract skills.

Research in cognitive psychology acknowledges that the human mind is most likely a powerful pattern recognizer. "Pattern thinking is very powerful, because it allows to think and reason by using the experiences a person has had. [...] Pattern thinking also allows to make guesses (predictions) about the world that go beyond our actual experiences."(Gee, 2003) This observation about how humans learn and understand the world has important implications. "If the human mind is a powerful pattern recognizer and the evidence very much suggests it is then what is most important about thinking is not that it is "mental", something happening inside our heads, but rather that it is social, something attuned to and normed by the social groups to which we belong or seek to belong."(Gee, 2003). This means social interaction can potentially improve learning by increasing motivation, fostering reflection, or boosting retention.

Many players enjoy social interaction in their games, but their behaviors and preferences vary. Bartles Taxonomy describes player behavior in MMORPGs (Massive Multiplayer Online Role Playing Games). He was able to identify four major player types.

Achievers want to achieve goals in the game. Their primary pleasure is challenge. Explorers want to get to know the breadth of the game. Their primary pleasure is Discovery. Socializers are interested in relationships with other people. They primarily seek pleasures of Fellowship. Killers are interested in imposing themselves on other players. They do this either by heavily competing with and defeating others, or by healing other players.

This demonstrates that developing games with social interactions might be very difficult especially if the designer wants to accommodate a heterogeneous group of players. As many serious games try to target very broad audiences social interaction design for them prove especially difficult.

3.5.2 Social Patterns Overview

Social interaction in games can usually be grouped into two major categories: competition and cooperation. While both categories are not mutually exclusive (some games incorporate both cooperation and competition), those categories are

still useful to identify and describe design patterns that can be used to support the respective categories. Collaboration patterns have the goal to increase teamwork, while competitive patterns aim to integrate competitive elements without demotivating more socially oriented learners.

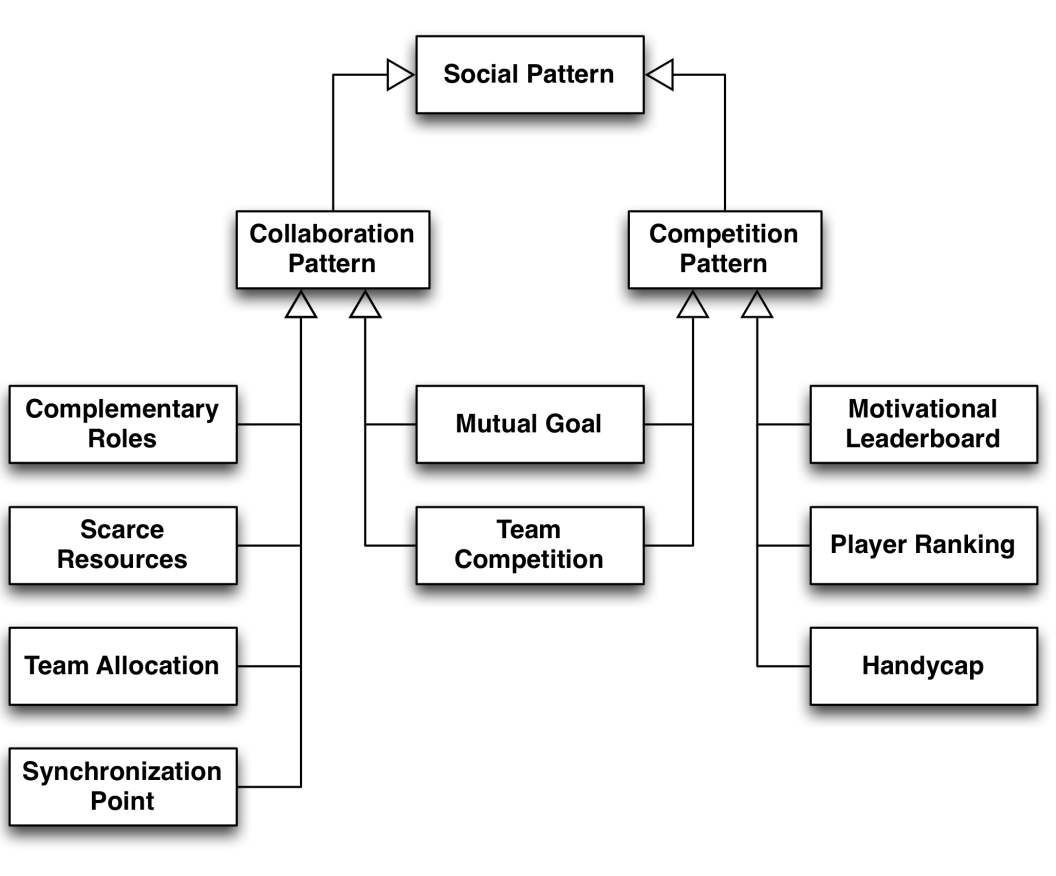

Figure 3.1: Overview over patterns for integrating social interactions in serious games. The patterns are categorized into collaboration and competition patterns, as well as patterns, that have both collaborative and competitive aspects.

3.5.3 Collaboration Patterns

Collaboration can be used to trigger learning mechanisms like induction, deduction or compilation, as it induces learners to explain and argue about what they have learned. Furthermore collaboration provides motivation for some players, especially those who focus on interacting with other players (Socializer and Killers). In a collaborative game those players are not only fending for themselves, but are part of a bigger team, which they want to succeed. Finally collaborative games can help students improve their teamwork skills. This chapter subsection describes four serious game patterns that integrate collaboration into serious games.

Complimentary Roles Pattern

also known as: Asymmetric Play

Some content is too complex to keep all of it in mind at once and focusing on one aspect at a time helps in learning it.(Kiili, 2007) Reflecting on different worldviews is an important goal (probably then competition is part of the equation, e. g. the common goal is to successfully lead a state, but each player leads their own department, with its own goals). Practicing cooperation is the main goal.

The goal is to create a game where the content is too complex for one person to keep all of it in mind at once. This makes it necessary to allow players to focus on one aspect at a time.(Kiili, 2007) The game should provide opportunities for discussion that can trigger reflection.

- It is ok to only have a rough understanding of the content that can be learned with the other roles.
- Observing other people in their roles already gives a good idea about the learning content.
- The content facilitates the creation of different roles. Roles do not feel artificial.
- People need to be able to play different roles.
- Probably requires a computer for every role. Therefore hard to implement in schools, where teams usually share one computer.
- Implementing multi-player over network can be work intensive. Finding a way to make different roles work on one screen can be a tough design problem.
- Communication becomes very central to a game with different roles, the game needs to support that communication.
- Creating a single player experience for the same game might be hard up to impossible. This obviously limits the contexts in which the game is viable.
- Shy players might have a hard time to join a team if they have to do so by themselves, providing automated matchmaking when possible, could reduce this stress
- Learners might prefer real life collaboration(Hummel et al., 2011)

Therefore: Provide the players with roles, which clearly differ in some regards. For example, the roles could have different goals for success, a unique skill set, or access to information.

Benefits:

- Reduction of cognitive load to part of domain required to fill out the role
- Communication with other players enforces externalization of knowledge schema. This can trigger reflection especially when the current internalized schema does not seem to fit that of the other players.
- Replayability increases, as playing the game with a different role can provide a fresh and interesting perspective.

Liabilities:

- Increased cognitive load due to continuous need for communication
- Increased development time and cost because each role requires additional resources
- Asymmetry can lead to a game that is not fair and balanced. Additional time needs to be invested to make sure every role is equally powerful and interesting to play.

The serious game AquacultureHummel et al. (2011) allows players to take on the role of a project leader, who investigates and draws up a feasibility report on what would be the most suitable location to start a new shellfish production site in a saline Vokerak Zoom Lake (VZL). After the creation of the first report, players are asked to choose between writing a report with a focus on ecological or governance perspective. The respective other part is done by a player, who took on the other role. The researchers decided on this design due to the complexity of the topic and because they wanted students to reflect on models and perspectives of other players.

In Americas Army[a], a recruitment game for the US army, players take on different roles (rifleman, automatic rifleman, grenadier, and squad designated marksman), which differ in equipment and movement speed. This forces players to cooperate as a team. The multiplayer online game League of Legends allows the players to select between different characters. However to form a successful, team players need to coordinate their selection to cover different roles, otherwise it becomes extremely hard to win the game. Those different roles are usually one character that deals physical and one that deals magical damage, a support character, a tank that draws damage towards him, and a jungler that secures helpful boni and money for his team. The game can only be won when players work together effectively using their characters strengths.

[a] www.americasarmy.com

Scarce Resources Pattern

Limiting resources like time, materials, information and space can encourage players to cooperate, as winning the game by oneself is hard if not impossible. In addition to limiting resources the game can then foster cooperation by providing the players with means to actively trade those resources. This creates exciting ways of interaction.

Synchronization Point Pattern

Stronger players drag along weaker players. This can have two effects. First the weak player does not even realize gaps in knowledge and understanding. Second

the other players continue to breeze through the game coming to points where it becomes only frustrating for the weaker player. At this point the weaker player is also not able to learn effectively anymore. A possible solution could be synchronization points where the game does not continue until all players manage to proceed. This encourages more experienced players to explain concepts to weaker players, hence improving both of their learning outcomes.

3.5.4 Competition Patterns

Competition can be a strong motivator to improve oneself. But it also always implies the possibility of failure, that can be demotivating. The goal is to integrate competition into serious games in a way that keeps motivation high for competitive players, without decreasing motivation for all others.

Motivational Leaderboard Pattern

The game teaches content where a direct comparison between players is possible via a score. The score should allow for competition between players and allow players to see how well they performed using a leaderboard.

Motivational effects of leaderboards depend on performance.

For many players competition is a motivator that greatly increases replay value. However it is common to find very high scores on leaderboards, which most players are not able to match even with lots of practice. This can be highly discouraging especially for beginners.
This notion is grounded in observations by the psychologist Marty Covington who observed competition in a classroom setting and came to the conclusion that creating competition over a limited number of high grades is more hurtful to motivation than helpful. He bases this finding on the belief that the root of motivation is a sense of self-worth. Competing for top grades is motivational only when there is a chance of obtaining them, otherwise the only way to preserve a sense of self-worth lies in not trying, since failure can be perceived as a lack of effort rather than a lack of intelligence. As a result, the inevitable result of scarce rewards is that there will be students who try hard but are not rewarded, which threatens self-worth and reduces motivation to work hard. The focus of the exercise becomes the competition, rather than the appreciation of the subject matter itself.
Covington (1992) writes: "When conditions of scarcity [of A and B grades] prevail, failure is more likely to be interpreted [by students] as a matter of personal inadequacy, whereas success was often seen as the result of chance or good fortune. ... Failure created self-loathing, especially in those students who were high in self-perceived ability. This suggests that under competitive goals, individuals are likely only to continue striving only for as long as they remain successful. No one wants to continue if the result is shame and self-recrimination."
Furthermore leaderboards, exactly like grades, often reduce the multiple dimensions of performance into one score. As improvements in one area of the game might not automatically lead to an improvement in score, this learning progress becomes invisible to players, which is detrimental for motivation.
Comparing yourself to other is motivating to some people. Simply removing the leaderboard might help the players, who feel distress from this comparison, but those who thrive on it would be left out. Using a local leaderboard, both player types can profit.

Therefore: Leaderboards should not show the rank within all players worldwide. Instead they should show only parts of the leaderboard. The selection criteria of the leaderboard can either be the score (only show immediate neighbors, e. g. closest 9 four of which are better and five of which that are worse than the player) or by acquaintance, e.g. show friends only or other group criteria like location, e.g. score within Germany, and time, e.g. only last week.

Benefits:

1. All players can push their limits and that of the game within a competitive environment. This can increase replay value of a serious game, which in turn can help retention, as repetition has been shown to improve memorization.

2. Beginners are not overwhelmed with high scores that seem unobtainable to them.

Liabilities:

1. The existence of more than one leaderboard or showing different aspects of the leaderboard can be confusing. Especially understanding the exact positioning within the ranking might become hard to determine.

The serious game INNOV8 by IBM[a], which allows players to learn about Business Process Management, does not only have one global leaderboard. Instead there are several leaderboards for different categories (supply chain, traffic, service).
The popular running game Nike+[b] allows runners to compare their scores with others. The leaderboards are per default shown only for the last week and all runners. However it is possible to change the time scope and limit the leaderboard to friends only.
This kind of leaderboards is especially common in casual games, which are targeted mainly towards players that just want to play occasionally and do not want to be confronted with fierce competition. For example farmville only displays a leaderboard including friends. Furthermore as a default the player is displayed as second best to the right in combination with a number that indicates his absolute position in the leaderboard amongst his friends. Only by scrolling will he be shown how many of his friends are actually better than him. While the player still sees his relative rank within the group of his friends precisely he does not feel discouraged by having to endlessly scroll until he finds his standing in the ranking.

[a]Play INNOV8 at www.ibm.com/innov8
[b]Nike+ www.nikeplus.nike.com

Player Ranking Pattern

Within the players of a serious game, there can be differences in previous knowledge and learning speed. Entering direct competition within a game, makes this differences very visible, which can lead weaker players to draw back from gameplay altogether, as they do not feel that they have a realistic chance to compete. On the other hand stronger players can easily become bored, when they do not find their opponents challenging. One possible solution to this problem is to create fair and exciting matches by calculating a rank for every player. Possible metrics that make up rank could be win/ lose ratio, estimated skill taken from a learner model, or number of matches. This is a similar approach to ELO Levels in chess.

Handycap Pattern

Differences in players skills can lead to tremendously unfair matches. Those matches are boring for the winners and often frustrating for the losers. Adding a handicap that increases the difficulty for the more proficient players levels the playing field. The handicap can either be static throughout one match, or even

adapt dynamically dependent on the in-game situation. Possible handycaps include limited resources, higher number of points required to win, or obstacles.

3.5.5 Combination of Collaboration and Competition Patterns

So far we have looked at patterns which support either cooperation or competition. Next we describe patterns that combine collaboration and competition. While this can increase long-term replay value and allow discovery of multiple aspects of a problem, it unfortunately increases the complexity of the game for players, as they often require a lot of multi-tasking. For example players then need to play the game, communicate with their team members and also react towards a much less predictable opponent. Some of those patterns therefore might not be applicable when targeting casual players.

Mutual Goal Pattern

The players, or some of players, try to reach the same goal or sub goal within the game. This pattern occurs whenever more than one player has exactly the same goal, e.g. "we both want the red car to come first" and not "we both want our respective cars to come first" (which are symmetrical goals). Mutual goals can be predefined goals that are either known or unknown before game play begins or goals that are Player-Constructed Closures with rewards defined by the players.

Team Competition Pattern

In inter-individual competition knowledge sharing is counterproductive, which reduces learning potential. However, the gameplay ("performance oriented stimulation", Bateman and Boon (2005, p. 27) is reduced in cooperative situations. This pattern helps to design a game that allows for competition, while still tapping into the power of information exchange between learners. Oftentimes creating a computer opponent for a specific game is hard or impractical. In order to create an exciting game, that still allows for knowledge sharing it might be helpful to have teams play against each other.

Chapter 4

Evaluation

Making a good game is hard. Making a good serious game is even harder.

Winn (2008)

This chapter contains the studies done during this dissertation. Section 4.1 describes an exploratory school survey. Section 4.2 describes a qualitative study on designing a cooperative game for preschool children. Section 4.3 demonstrates an evaluation process that can be used to measure the effect of applying a pattern.

In the previous chapter we identified and demonstrated the usage of several design patterns, to improve serious game design by integrating social interaction. However, we did not show the effectiveness of any of those patterns, neither by itself, nor in comparison to other patterns. A systematic evaluation of those patters could be very interesting. However even given such an evaluation, it seems most likely that the effectiveness highly depends on the game, its content, and target group. This means the effectiveness cannot be shown with one single study, but several studies.

4.1 School survey

Before the development of serious games patterns, we wanted to find out more about the potential players of serious games. One major application area for serious games are schools. Hence we wanted to find out, more about how and what students play.

4.1.1 Study Design

In order to evaluate attitudes towards and experience with serious games, we designed a questionnaire. The questionnaire started out with some demographic

questions, next it asked about computer games in general, then about school subjects and lastly about serious games.

The goal was to get a picture of game play behavior of the students, their interests in school and then see how both influenced the attitude toward serious games. The full questionnaire can be seen in appendix B.1.

Environment

In order to get not only answers from students who might be interested in the topic of serious games by themselves, we did not do an online questionnaire. Instead we went to two different schools, where we distributed the questionnaire in five different classes between 6th and 10th grade. In addition, some students filled out the questionnaire at 'Lange Nacht der Universität' answered the questionnaire.

The schools were Klenze Gymnasium München, where we went to sixth and tenth grade in July 2015 and Johann-Schöner-Gymnasium, where we went to sixth, eighth and ninth grade. The students received time to fill out the questionnaire during their class time, with the support of their teachers.

Participants

In total 136 pupils, consisting of 46 boys and 63 girls (another 25 did not want to specify), handed in a completed questionnaire. The pupils all went to grammar school between grade 6 and 10. This means they were between 12 and 17 years old. More specifically, there were 20 sixth grade students, 62 eighth grade students, 27 ninth grade students, and 9 tenth grade students. Another 16 students did not specify the grade they went to.

4.1.2 Results

With the questionnaire we mainly wanted to find out, how students play games, how often they play and what kind of games they prefer.

At first let us have a look at frequency and duration. When asked how often they play games, most students (39% answered that they play several times a week. In addition, 31% even play on a daily basis. Another 6% said that they still play several times a month. Looking at these results, we can say that the majority (76%) of students are very familiar with games and enjoy them as a past time.

Only 24% stated that they play less than once a month or never. Also 2% did not answer the question at all. The summary of the answers can be seen in 4.1.

In addition to the frequency, we also asked students, how long they usually play in one session. With 45% the largest group plays longer than a few minutes, but less than an hour. The second largest group (34%) even plays for hours when

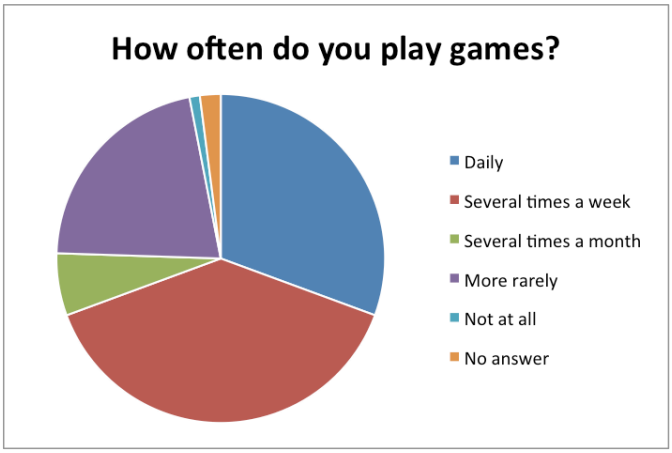

Figure 4.1: Frequency with which students play games.

they play. The rest casually plays for a few minutes (17%) or not at all (1%). 3% did not answer the question.

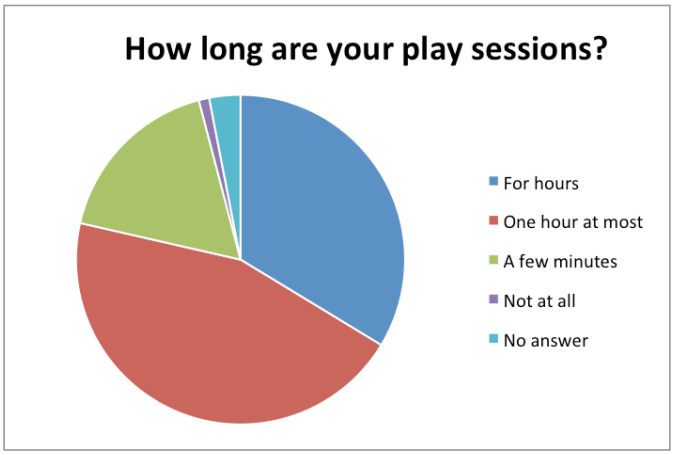

Figure 4.2: Self-reported duration of an average play session.

We also wanted to find out, where students play most frequently: at home, at a friends' place or on the go. The big majority (70%) plays at home. Much smaller numbers claim they mainly play at a friends' place or on the go. This can be seen in 4.3.

We were also interested to find out whether there is a connection between duration of the game sessions and where students play. When looking into a connection, we found out that students who play longer tend to play at home. In this group 79% said they play at home, while 13% play at a friends' and only 7% play on the go.

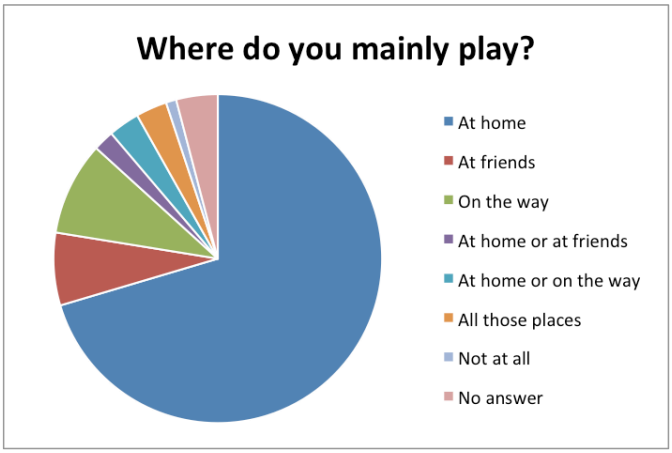

Figure 4.3: Location where students prefer to play games.

In comparison, students who play for one hour at most play 72% at home, 13% play at a friends and 15% play on the go, this is twice as much as students who play for hours. Unsurprisingly with 27% the percentage of students who play on the go is even bigger for students who only play a few minutes at a time. The rest 72% play at home. No students answered that they play only for a couple of minutes when they are at a friends'.

Now that we know how often and long students play, we wanted to know a bit more on what kinds of games they play. So we asked them for their three favorite games. Unsurprisingly, we got a variety of answers. We then categorized the games.

Furthermore, we asked students whether they mainly played alone, with, or against others. The results can be seen in 4.4. We can see that most students prefer to play either with or against someone. Only 13% of students say they always prefer to play by themselves. 21% of students say it really depends on the situation.

What we can see here, is that students do not see games as something that they play in isolation, but with and against friends. However when looking at serious games for learning, we can see that many are still exclusively focused on single player mode.

After we have established the relation of students to games in general, we wanted to know about their attitude towards learning games. Hence we asked them, whether they know any learning game they like. With 70% the majority said they did not, while only 20% said that they know one. 10% did not answer the question.

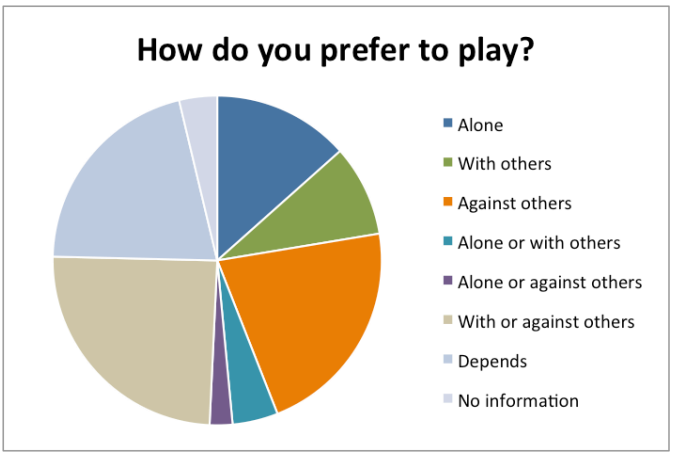

Figure 4.4: Students report their preference to play alone, with, or against others.

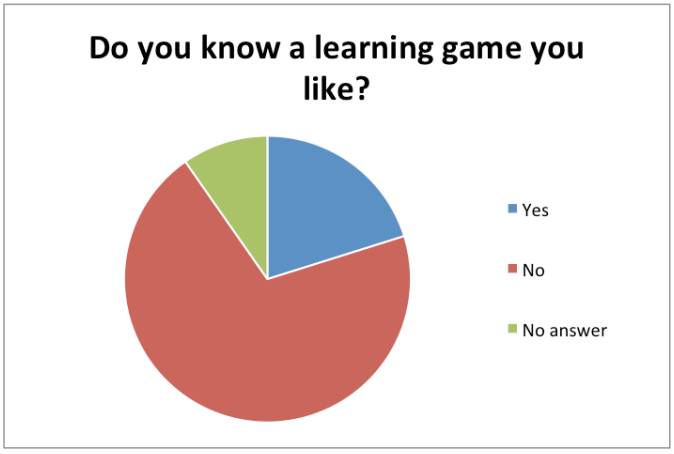

Figure 4.5: The majority of students stated, they do not know a learning game they like.

We think this result shows that learning games still have a far way to go. Learning games only appeal to a small set of students. Two ways to increase interest can be to integrate social interactions, as most students said they do not play by themselves, but with or against others. Additionally, we saw that students play games of very different genres. This means it is impossible for one serious game to appeal to all students within a classroom. Instead different types of games should be developed. Some more casual, supporting game sessions of only a couple of minutes, some epic, allowing for play times of several hours.

4.1.3 Threats to Validity

While the survey tries to get an accurate picture of how students play computer games by including students from different age groups, the transferability of the results is still limited. As all school classes that participated were from border schools in Germany, the results can very likely not be transferred to other countries.

Additionally the results rely on accurate self-reporting. For example students had to estimate by themselves how often and how long the played. Hence the given results might not be precise. However they still can give us a rough estimate.

4.2 Case Study: WeMakeWords

In a cooperation between the Chair for Applied Software Engineering and a child psychologist, we implemented a cooperative game to teach simplified chinese characters to young children between ages 4 to 8. The project included two supervisors from the chair, the child psychologist. and five undergraduate and graduate students, who took over implementation and design.

The project was developed in increments, where short sprints of two weeks were followed up on by an evaluation of the game at the Child Psychology Practice Garmisch. The goal was to continuously improve the game, especially the aspect of social interaction, with every development step. Especially we wanted to find or establish patterns to ease cooperation between children.

The game was developed for the iPhone, as it allowed children to move while playing, instead of being bound to a computer screen. This mobility and flexibility was at the core of the game, as it would allow children to not only interact over a network, but also in person, even directly comparing their screens with one another.

During our survey in several school classes we found out that a significant amount of people do not enjoy to play computer games by themselves, or at least prefer to play cooperatively or competitively. This lead us to the hypothesis that serious games could profit from integrating social interactions.

Hypothesis 1 (Motivation) *Player motivation increases when social interactions are integrated into a serious game. This is independent of player age.*

While motivation is an important part of serious games for learning, it should not come at the cost of learning provided by the game. Hence, in cooperation with the child psychologist, we wanted to test whether it is possible to design a learning game with social interactions at its core without reducing or dumbing down the learning content.

Hypothesis 2 (Design for Social Interaction) *A serious game can be designed with social interaction at its core, without compromising the learning elements.*

Lastly, we wanted to see, whether we used any patterns in the game, which could be used in other games.

Hypothesis 3 (Serious Game Pattern) *The game design includes patterns for increasing social interaction that could be reused in other games.*

The study was meant as a small exploratory study and to collect first experiences with designing serious games that include social interactions.

Study Design

Environment weMakeWords is a game that helps children to learn reading chinese characters. At the suggestion of the child psychologist the goal was to foster collaboration as a core game mechanic.

For the study a minimal viable product (MVP) of the game was developed. It included 20 simplified chinese characters for different animals like horse or elephant. While the game also works with alphabetical languages like English or German, for the study we focused on simplified chinese, as this ensures that no participant would have prior experience in the domain. Furthermore the game was limited to a set of 20 characters in order to quickly see learning results.

The study consisted of three phases, with the goal to iteratively improve upon the game and discover ways to increase collaboration and communication between participants. In the first evaluation phase the game was limited to single player mode in order to fasten implementation, but also to see how well a single player version of the game would be perceived.

In the single player version of the game the player is shown a picture of an animal. The goal is to assemble the chinese symbol that represents that animal from strokes. For this the player receives one stroke. He can then decide to dismiss it, by dragging it to the bottom, or to use it by dragging it onto the space for the

chinese symbol in the top right corner. The completed chinese symbol is displayed as a watermark. With every correct answer of the player it is faded out further. In case the player makes mistakes the watermark is made less translucent. Once the player has completed five symbols the game ends.

Figure 4.6: Screenshot of the single-player game mode of weMakeWords

In the second phase a simple cooperation mechanism was introduced. In the collaborative mode, up to four players can connect their devices with one another. They then do not only see their chinese symbol, but also the symbol and picture of the chinese symbol of their teammates. If they think the stroke they received is helpful to their teammate, they can send it, by dragging the stroke onto the teammates picture. Once every player has successfully completed five chinese symbols the game is won.

In the third phase the major game principles stayed the same as in the second phase, but we added a Synchronization Point pattern with the goal to increase collaboration.

Participants In the first phase five children from 4 to 6 years participated. Additionally, four students in their early twenties took part. In the second phase the game was evaluated with 8 children playing cooperatively in two groups of four. Also two student groups with three players each playtested the game. Lastly in the third phase we evaluated the game with 20 participants, 20 children from the child psychology practice in Garmisch and 9 students from a practical course. The children were ages 4 to 6, while the students were in their early twenties.

Figure 4.7: Screenshot of the multi-player game mode of weMakeWords. To the right is the players own symbol. The small symbols to the left are the teammates symbols.

All participants were familiar with mobile devices, although not with the iPhone in particular. None of the participants had any prior knowledge on chinese characters in general or simplified chinese characters in particular.

Data collection methods In the first play session, participants played the single player version of the game. We observed whether they got stuck and how long they wanted to play by themselves. After the play session, we interviewed the players and had a small session, where we asked them to recognize simplified chinese characters.

During the play sessions in the second and third phase, we carefully observed the participants especially with regards to social interactions. This means we noted how often participants would get stuck, whether this lead to them asking for help, and whether the other players would provide help. The goal was to find out, how much players would cooperate. Subsequently, we did a brief interview and again asked players to recognize simplified chinese characters they had just seen during the game.

	Phase 1		Phase 2		Phase 3	
	Children	Students	Children	Students	Children	Students
Male	2	3	5	5	12	6
Female	2	1	3	1	8	3
Total	4	4	8	6	20	9

Table 4.1: Overview over participants of the case study

Observations

Players reported that the game was already fun in its first iteration, where they could only play by themselves. However they also found that after a relatively short play time, it became somewhat less engaging, as there was too little variety after more than a quarter hour.

In order to evaluate learning outcomes, we showed the chinese characters to the participants and asked whether they could recognize which animal it belonged to. Children ages 4 to 8 could on average remember six symbols, while the young adults could remember around eight symbols.Ismailović (2014)

In the second phase, participants could cooperate, by sending strokes to their teammates. While the children enjoyed interacting with one another for example by showing of their pictures to one another, they rarely communicated with regards to the learning content. Instead most children concentrated on completing their five symbols as quickly as possible and then spent the rest of the game waiting for their teammates with a bored expression. On the other hand the slower children sometimes were frustrated, when some of the quicker children told them to hurry up. With adult participants the effect was not as pronounced and they more easily took up the cooperative aspect of the game.

At this step we were also interested in how the social interaction effected the learning goals. As the content between the first and second version of the game was the same, only changes in the game structure could change learning outcomes. As in the previous phase, we asked participants, which of the chinese symbols they recognized. As far as we could observe there was no major difference in how many symbols they could remember, which means the social interaction did not

negatively impact the learning outcome.

In the third phase we wanted to increase collaboration. Hence we analyzed the observations from the previous step for reasons, why the children did not cooperate more. The major observation was that every child was keen on finishing its own symbols as quickly as possible. This sometimes went so far that some children did not even perceive the possibility that they could help their teammates.

Because of this we decided to add a Synchronization Point after every chinese symbol. This means, that the game would not hand out a new chinese symbol to the participants until every participant has completed their symbol for the round. When we observed children, they would quickly notice that they did not receive a new symbol, even though theirs was completed. When their teammates would take a while to complete their symbols, they quickly became bored as they did in the end of the game in phase two. At this point the instructor would tell them that they could help their teammates. As they could not rush on with their own symbols, in the third phase of the study the children after only this small prompt readily helped their teammates. In contrast to the second phase they also would not just send a stroke, but instead try and explain to their teammate they sent the stroke to, why it fits.

When evaluating the learning outcome during third phase, there was a small increase in how many symbols participants remembered. This means it is relatively unlikely that the social interaction reduced learning outcomes. However, as the number of participants was small, we also cannot show that social interaction might even improve learning.

Threats to validity

In order to increase validity of the case study several steps were taken. First of all, in order to increase confirmability, the development and evaluation were conducted by two different groups. Development was taken on by the development team that participated in the practical course, while the evaluation was done by a supervisor from the chair and a child psychologist.

Second, the evaluation of the same game with two different age groups, shows that the results are not limited to only one target demographic. While transferability cannot conclusively be shown this is a start in the right direction. One result of the study was the Synchronization Point pattern, which is clearly applicable to other serious game.

However the small number of participants in the study limits generalizability of the results. Evaluating the patterns on other games, with different target groups, would increase the credibility of the Synchronization Point pattern.

4.3 Experimental Study: Evaluating the Motivational Leaderboard Pattern

The goal of this study is to evaluate the effect of the motivational leaderboard pattern. The difference between the motivational leaderboard and a classical leaderboard is that it shows the score of the player in context of his direct neighbors, whereas a classical leaderboard starts with the highest scores at the top. As a result a player might not even be able to see how well he did without scrolling.

This pattern can be used in any context where performance can be clearly rated via a score. The pattern was evaluated within the *Patterns for Software Engineering* lecture in the winter semester 2015/2016 using a controlled experiment.

In the evaluation of the motivational leaderboard pattern three hypotheses are regarded:

Hypothesis 1 (Motivation) *Players who are shown a motivational leaderboard are more motivated.*

As motivation cannot be measured directly, the hypotheses is broken down into two more specific hypotheses:

Hypothesis 1.1 (Play duration) *Players who are shown a motivational leaderboard on average play longer.*

Hypothesis 1.2 (Number of matches) *Players who are shown a motivational leaderboard play more matches.*

In addition to motivation, we expect the motivational leaderboard to have an effect on the players mood.

Hypothesis 2 (Mood) *Players who are shown a motivational leaderboard enjoy the learning experience more and are less frustrated.*

We validate the mood using the Game Experience Questionnaire (GEQ)(IJsselsteijn et al., 2008)

As a result of **Hypotheses 1** and **Hypotheses 2** we expect the following hypotheses to be true:

Hypothesis 3 (Performance) *Increased motivation and mood from the motivational leaderboard lead to an increase in performance, where performance is regarded as the ratio of correct to wrong answers as well as the answer time.*

We hypothesize that the motivational leaderboard increases motivation and mood of the players in comparison to classical leaderboards, as the player gets the opportunity to compare his own score to players with similar scores. This allows him to set the realistic goal of overtaking the player who is only marginally better than him. In contrast, in a classical leaderboard the player compares his own score to that of the best players. Those scores might seem impossible to reach leading the player to perceive his abilities as low, which according to the compensatory model of work motivation and volition in figure 2.10 can lead to a decrease in motivation and lead to a feeling of frustration and incompetence. As a result of increased motivation and mood we expect players to improve their performance in the game.

Study Design

We validate the leaderboard using a controlled experiment. The experiment took place over the duration of two weeks at the end of the elective lecture *Patterns for Software Engineering* in winter semester 2015/2016.

For the experiment students were at first asked to answer questions about personal information like age, field of study, degree, and semester. After that they were randomly distributed into two groups. At the end of each quiz session the first group was shown the motivational leaderboard, while the other group was shown a normal highscore, starting with the most highly ranked players. After five quiz sessions the players were shown the game experience questionnaire.

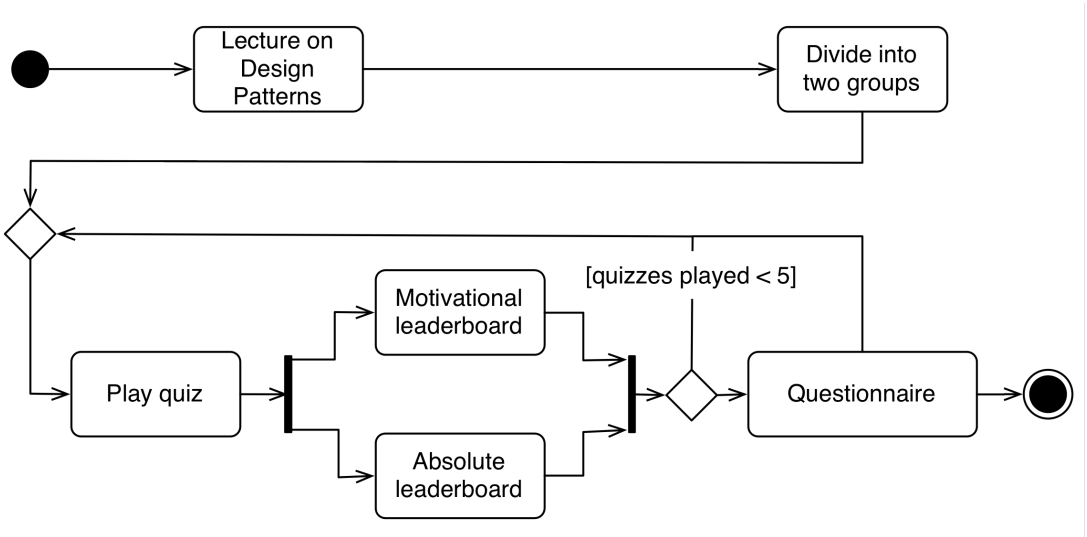

Figure 4.8: Overview over study design

For the evaluation both objective and subjective data were collected.

Objective data were monitored and recorded by the quiz game and stored in a database. The data included:

- The start and end time for each quiz played, which allows to calculate the precise duration of the play session
- The answers given by the player to the knowledge questions posed by the quiz.
- The time to answer for every question in seconds.

Subjective data on the mood of the players was collected using the in game version of the Game Experience Questionnaire (GEQ)(IJsselsteijn et al., 2008). The GEQ was specifically developed to evaluate game experience and measures the seven components: immersion, flow, competence, positive and negative affect, tension, and challenge. As the questions regarding immersion ask about story and impressive graphics and audio that are not applicable for a quiz game, these questions were emitted from the original questionnaire.

In the questionnaire players indicate how they felt while playing, by ranking statements like "I felt successful" on a five point likert scale going from *not at all* to *extremely*.

The combination of objectively measurable data and subjective description of mood allows for an evaluation of the given hypotheses.

Environment In the lecture Patterns for Software Engineering students learn about a variety of topics from design patterns, architectural patterns, antipatterns to testing patterns. Goal of the lecture is to teach students to understand and apply patterns in software projects. To this purpose we embed programming and modeling exercises into the lecture. While the concept works fairly well and is quite popular with students, we realized that sometimes students would struggle with basic concepts. When regarding Bloom's taxonomy (Krathwohl, 2002) we realized that some of those problems might stem from insufficient effort spent on studying on the recall of facts, which according to the taxonomy are a prerequisite for understanding and application.

Studying facts can be repetitive to students, hence we wanted to wrap it inside of a quiz game and include competition based on a leaderboard. For this study we implemented a quiz game with around 200 questions about the lecture material. In the quiz the player has a limited time of 30 seconds to answer a question. As soon as the time is up, or when the player answered a question wrongly, he loses one life. The game ends as soon as he lost all three lives.

At the end of the game, the player is presented with his score during the match. When he continues he is presented with a leaderboard. Two different

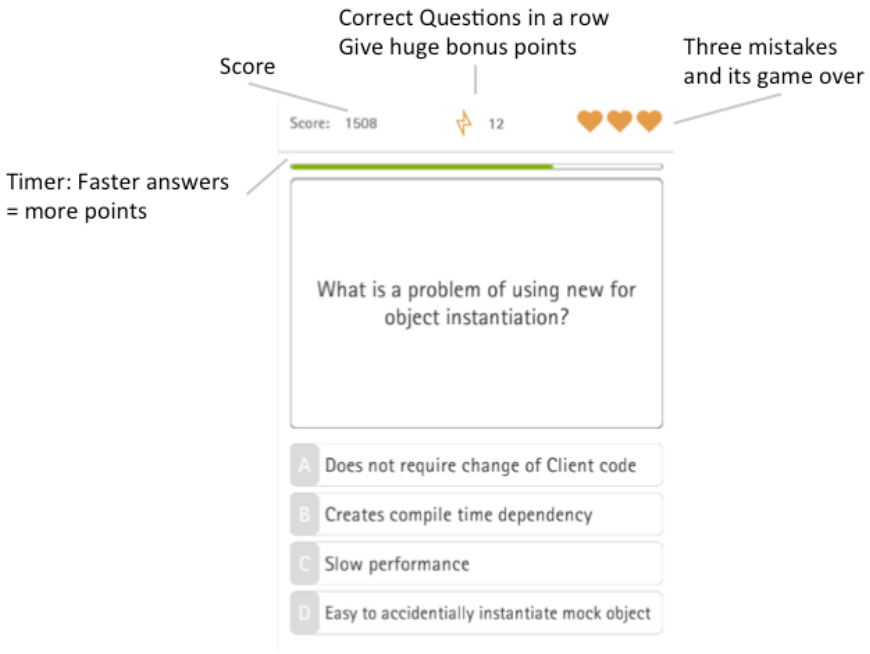

Figure 4.9: Screenshot of the quiz with explanation overlay

versions of leaderboard were implemented. The first leaderboard always presents the top players, while the second leaderboard depicts the current player in relation to other players.

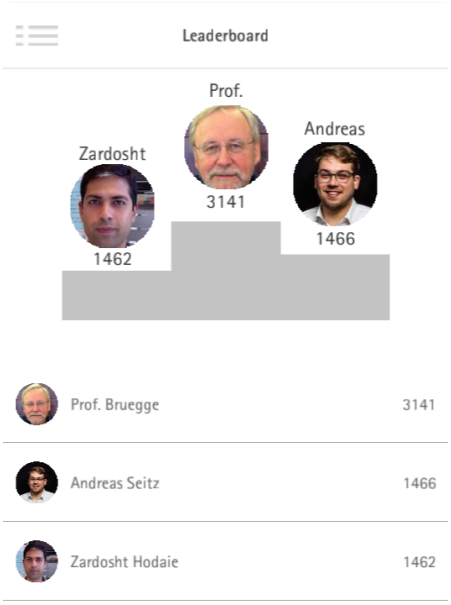

Figure 4.10: Leaderboard

In the screenshot an example leaderboard can be seen. Between the two conditions for the leaderboard the overall layout was not changed. The only difference is that in the motivational leaderboard the player always sees his own score in second place, while in the normal leaderboard the best players are shown at the top. This means in the motivational leaderboard he can directly see where he stands in comparison to other players, while in the normal highscore he might have to scroll very far to see his actual score.

Participants The lecture on *Patterns for Software Engineering* in the winter semester 2015/2015 had 489 registered students of whom 235 participated in the final exam and 340 registered in the quiz. 306 students played at least one session until its end and 120 students filled out the questionnaire which appeared after 5 matches. With 98 students the majority are male, 13 are female, and 9 did not want to answer the question. The average age of the students is 24.

The majority of the students is currently enrolled in a master program (81), the second largest group are bachelor students (31) and only 8 students are enrolled in a different program.

Results

The 340 players were placed in two experimental groups of roughly the same size. Group 1 with 168 players was shown the classical leaderboard at the end of each match. Group 2 with 172 players was shown the motivational leaderboard.

The first hypothesis stated that players are more motivated when they are shown a motivational leaderboard, which should lead to longer play time and more matches played.

In total players played 8 days and 18 hours. Group 2 played 5 days and 2 hours, while group 1 played 3 days and 16 hours. That is, players who were shown the motivational leaderboard spent 38% more time on the game.

To break these numbers down to how much time players spent per match on average. We considered only players who finished at least one match, because players that aborted before the end of the first match, were never shown any leaderboard. Hence they could not behave differently based on that criterion.

Considering only players who finished one match or more, the mean play time per match for the 151 players in the control group was 3:24 minutes. The mean play time per match for the 155 players, who were shown the motivational leaderboard was 3:53 minutes. This means that players who were shown the motivational leaderboard on average played 14% longer.

Simply measuring the difference in mean play time per match, does not tell us, whether the effect is significant. To calculate significance we use a t-test to compare the means. The p-value for the two distributions is 0.41. This means there is a probability of 59% that the differences only occur due to sampling effects. So while there is a difference in average play time per match, it cannot be certainly stated that the difference is significant.

This changes when regarding players who played at least five matches and the effect further increases when looking at players who played more than ten matches. Figure 4.11 illustrates the increase in average play time per match. Of 306 players 155 finished five or more matches. 81 of those players were shown a motivational leaderboard and 74 were shown a classical leaderboard. In the first group the average play time per match was 3:40 minutes, in the second group it was 3:09 minutes. This means players who were shown a motivational leaderboard played 48% longer. The p-value in this condition was 0.11, which means that with a probability of 89% the difference is explained by the usage of different leaderboards.

When we analyze the group of 102 players who played more than ten matches, the difference in average play time per match is even bigger. The 51 players who were shown a motivational leaderboard played 4:05 minutes, while the 51 players in the control group played only 3:14 minutes. So players who were shown a motivational leaderboard played 67% longer than the control group. The p-value

for these samples was 0.14.

Players who played more matches also played longer, which confirms our hypothesis. As we assume that classical leaderboards are frustrating the player hence leading to decreased motivation and shorter play time. The more often the player is confronted with the leaderboard the bigger the frustration grow, the shorter the play times become.

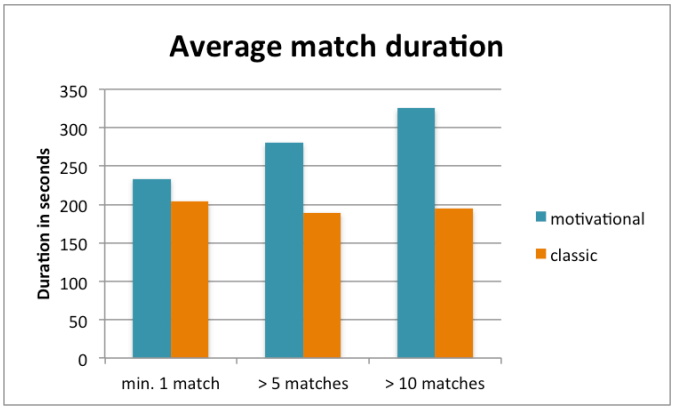

Figure 4.11: Average match duration for players by number of matches played.

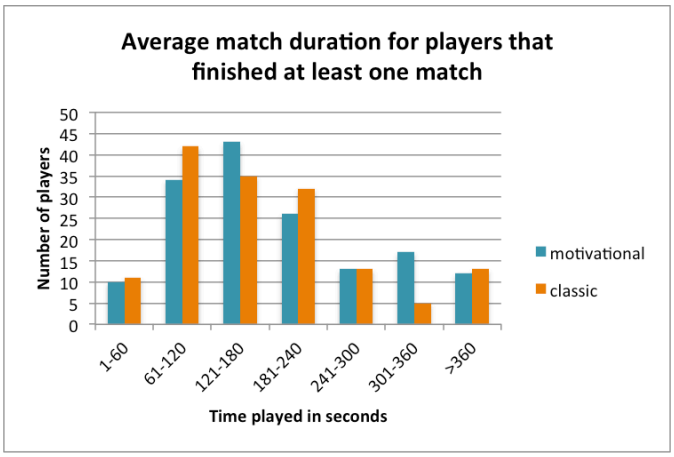

Figure 4.12: Comparison of play duration between motivational and classical leaderboard.

Just as the play duration, the number of matches is consistently bigger for players, who were shown the motivational leaderboard, than for those in the control group. On average players in the first group played 8.3 matches compared to 7.7 matches in the group, who were shown the motivational leaderboard. This is 7 % more. When we consider only the average of players who played more than

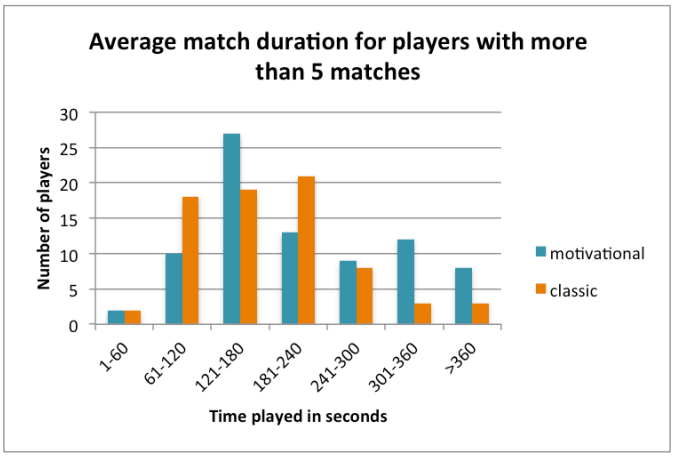

Figure 4.13: Change in average duration when only regarding players, who played more than five matches.

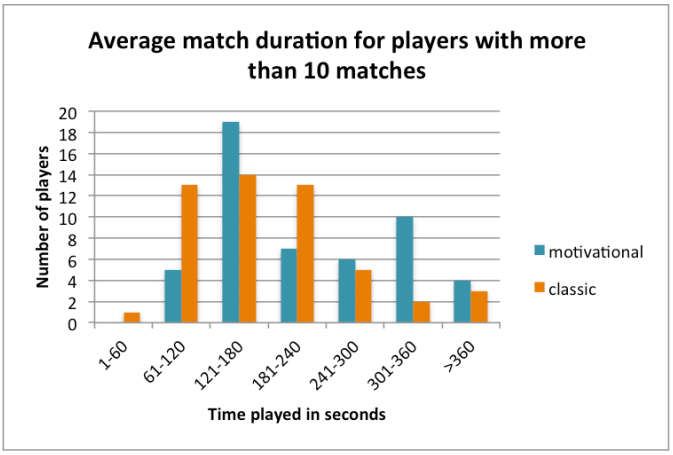

Figure 4.14: Change in average duration when only regarding players, who played more than five matches.

five matches, the difference increases to 8%. At more than 10 matches it is 15.6 matches and 14.4 matches respectively, which is a difference of 11.1%.

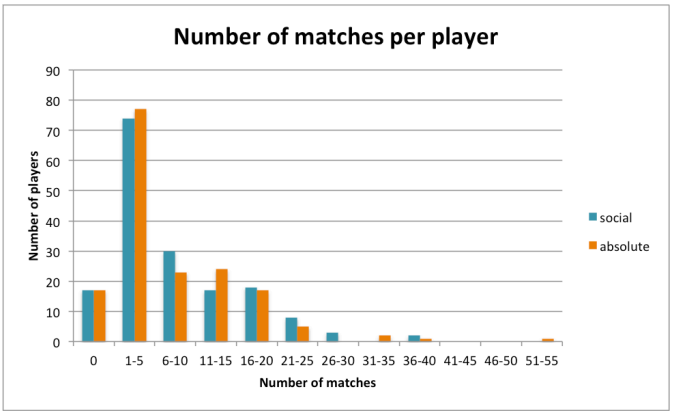

Figure 4.15: Histogram of the number of matches played. Most players played between one and five matches.

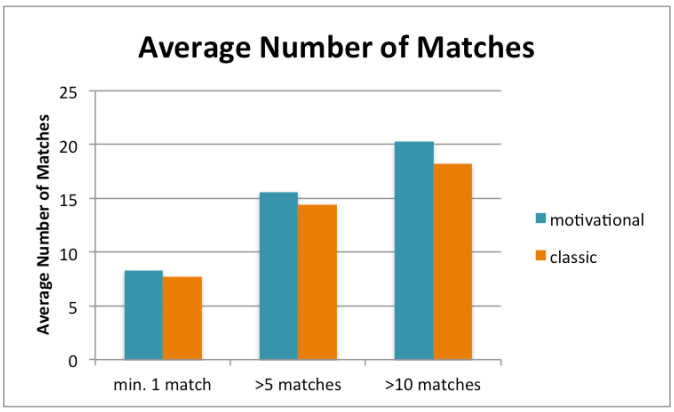

Figure 4.16: Comparison of average number of matches played between group 1 and group 2.

As we can see in figure 4.15 and figure 4.16 the number of matches played is higher for players who were shown the motivational leaderboard. However, once we calculate the p-values, it can be seen that the difference is mostly not significant. The p-values is 0.57380, when comparing all players, who finished at least one match. This is relatively close to the p-value of 0.63029, when regarding players who played more than 5 matches. Only when looking at players, who played more than ten matches, the p-value is 0.27502, closer to being a significant difference.

From this we conclude that the motivation for players, who saw a motivational leaderboard was higher. The total time played, as well as the average time per

match were consistently significantly higher than that of the control group. While the number of matches was also bigger, the difference there is not significant. But both values combined still support the hypothesis.

Next we want to evaluate the mood reported by the players when answering the GEQ(IJsselsteijn et al., 2008). We asked those questions after the fifth match, where we assumed the leaderboard already had time to effect mood. We used the In-Game version of the GEQ, that consists of 14 short questions. As the questions on immersion did not apply to a quiz game, we left out those two questions, and ended up with a shortened version of 12 questions. The questionnaire can be found in appendix B.2 The average of two questions is used to calculate scores for feelings of competence, flow, tension, challenge, negative affect, and positive affect. The results can be seen in figure 4.17.

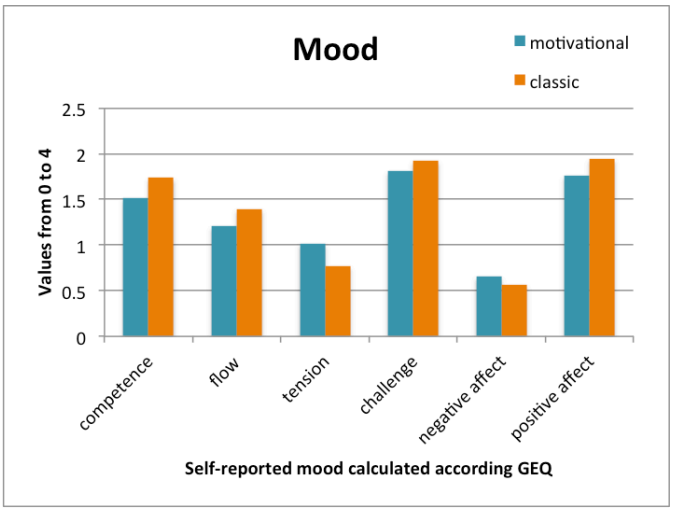

Figure 4.17: Evaluation of the GEQ shows little difference between the two groups.

According to our hypothesis, we assumed that players that are shown a classic leaderboard report more negative feelings of tension and negative affect, while the motivational leaderboard brings a positive feeling of flow, challenge and competence. When we look at the evaluation, we can see that the opposite was reported by players. However the differences are relatively small for all reported moods. When we analyze the p-values, we can see that the differences in mood reported are not only small, but also not statistically significant. The exact values can be seen in the table below:

As can be seen the lowest p-value is that for tension with 0.19, which is still not significant. Looking at the evaluation of the mood, we cannot find significant differences between the two experimental groups in either direction. Hence we cannot make a conclusive statement on the hypothesis. It would have probably

	competence	flow	tension	challenge	negative affect	positive affect
mean motivational	1.52	1.21	1.02	1.81	0.66	1.76
mean classic	1.74	1.40	0.77	1.92	0.57	1.94
p-value	0.25	0.31	0.19	0.54	0.57	0.30

Table 4.2: Means for GEQ answers by aspect and their respective p-values.

been good to additionally ask the same questions again after 10 turns, as differences might have been bigger then.

Lastly, we want to evaluate the most important criterion: performance. We assumed that due to longer play time and positive mood, the performance of players would be better, when they are shown the motivational leaderboard. For this we will have a look at the number of correct answers and wrong answers and most importantly the percentage of correct answers.

On average players who were shown the classical leaderboard answered 103 questions correctly, while players who were shown the motivational leaderboard answered 126 questions correctly. This is a difference of 23%. The number of wrong answers was nearly identical in both groups. For players, who saw the classical leaderboard it was 24, while it was 25 for the other group.

Now let us have a look at the ratio of correct to wrong answers. When we look at all matches, there is essentially no difference. On average players gave correct answers 76,4% of the time. Once players continue playing, the leaderboard starts to effect their scores. After five matches players who were shown the motivational leaderboard have become better than their control group. They now answer correctly 79,9% of the time, while the control group barely improved and is now at 76,7%. The p-value is 0,06, which means it can be considered significant.

Once we regard players after 10 matches, players who were shown improved further to 81,3% and their control group sees almost no improvement with a correct answer ratio of 76,7%. The p-value here is 0,02 again making the difference significant.

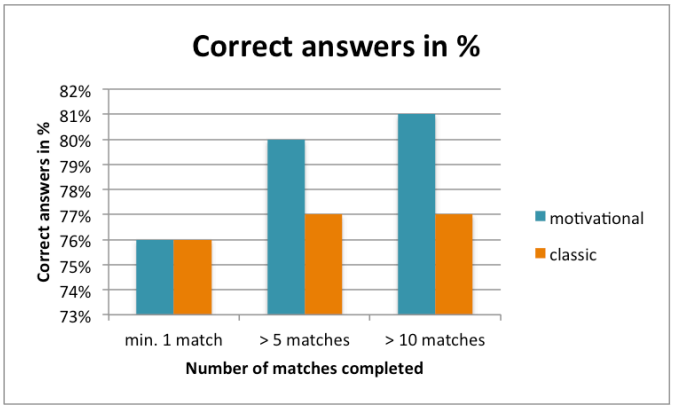

Figure 4.18: Correct answers given by players in percent.

When looking at the numbers, we can see that players, who were shown the motivational leaderboard saw bigger improvement in their performance, than the control group. After 10 rounds the difference was 6%.

In addition to accuracy when answering questions, we can regard average answer time as another indicator for performance. When we evaluate answer times after one, five, and ten matches, we can see that both groups answer more quickly with more matches. In the group, who is shown the classical leaderboard, the answer times are 10 seconds, 10 seconds, and 9.7 seconds. For players, who saw the motivational leaderboard answer times were 10.6 seconds, 9.4 seconds, and 8.8 seconds. As we can see the answer times decrease more for the group, who was shown the motivational leaderboard, which indicates a bigger learning effect. The p-values after one match, five matches and ten matches are 0.06, 0.15, and 0.03 making the results especially after 5 matches significant.

In summary, we observed that players, who were shown the motivational leaderboard, had a 6% higher correct answer rate and a 8% faster response time, indicating overall better performance. As the differences were significant, we can support our third hypothesis, that the motivational leaderboard enhances performance.

Threats to validity

Students were able to play the quiz game over the course of two weeks at any time they wanted. While this allows for more realistic measurement on how students would actually play a quiz game, it also adds several external influences to the experiment that cannot be closely controlled. For example over the course of the two weeks we could not track how much time every student spent on additional studies.

Furthermore the evaluation is limited to an audience of computer science stu-

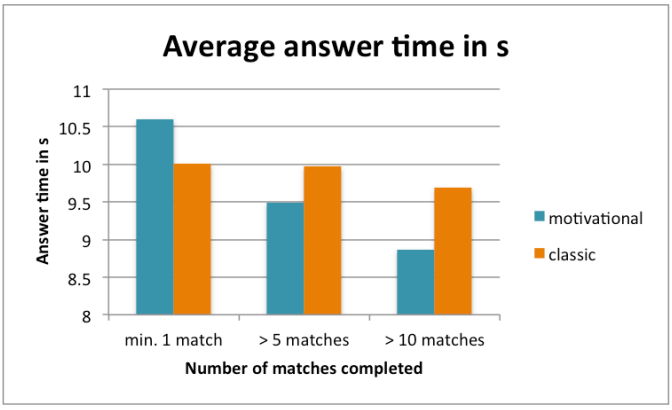

Figure 4.19: Even though the group who was shown the motivational leaderboard starts out with higher answer times, they improve much more than the control group.

dents, all of them young adults. This means the results of the study cannot easily be generalized to audiences in other age ranges or subject. Additionally the majority of students in the lecture were male. As there are studies indicating that gender influences on how competitive a person is (Andersen et al., 2013; Cárdenas et al., 2012; Thomas Buser et al., 2014), a group with more females might respond differently to the motivational leaderboard.

Another threat that should be considered is the validity of the subjective data given via GEQ. Not all students answered the questionnaire. The students who answered the questionnaire might in general be more motivated, hence giving a more positive view over the game. However, as students were randomly distributed into two groups this effect should be equally large in both experimental groups.

Even when students did answer the questionnaire, they did not take the same amount of time to consider each question. Very short answer times might indicate that players just checked arbitrary answers to some of the survey questions. To address this issue, we compared the data to results when only considering answers where students took at least 1 second to answer.

Chapter 5

Summary and Conclusion

We already have too much medicine that is (cognitively) good for the patient-who will not take it-and medicine that patients find delicious-but that contributes little to their cognitive abilities.

Simon (1995)

Serious games are interactive and provide information multi-modally through images, audio, and text. This gives them the potential to be great learning tools. The goal of this dissertation was to improve serious game design. In particular we investigated the role of social interaction on motivation and learning performance.

This topic was chosen after an exploratory study with 136 pupils (Section 4.1). In the study the students answered a questionnaire about their attitude and behavior towards games in general and serious games in particular. The questionnaire showed that most students today play computer games frequently. Play duration can be anywhere from a couple of minutes up to several hours. When playing at home play duration is usually the longest, while students who play on the go tend to play only for a few minutes.

When asked about serious games most students stated that they do not know any learning game that they like, but they are in general open to the idea to playing a game in order to learn. Over half of the students, who participated in our school survey stated that they almost exclusively play with or against others, while only 13% said they prefer to play alone. In contrast we noticed that only a small amount of serious games include any form of social interaction. As social interaction has also been proven to help in learning we identified this as an aspect in serious game research that should be regarded in more detail.

In order to inspire serious game designers to include social interactions, we developed social interaction patterns for serious games. We did this by analyzing existing games and serious games that include social interaction and extracted their approaches to social interaction into serious game patterns. Furthermore,

we adopted existing patterns from game development and educational design to the context of serious games. We then grouped the pattern into the the categories competition and cooperation.

Next we evaluated two of the patterns empirically on two games developed in the chair for applied software engineering. The first game was weMakeWords (Section 4.2), a game about chinese characters developed in cooperation with a child psychologist. When we integrated the possibility to interact with teammates through the game, we observed higher levels of engagement. This effect became bigger the longer participants were playing the game. This could partially be due to the fact that participants in the beginning are still busy to figure out the rules of the game. In addition participants might take a while until they get to know their teammates, making them more likely to interact with one another. In general we observed that social interaction increased engagement, while it did not negatively impact the learning outcomes. Furthermore we identified the Synchronization Point pattern, as a means to increase collaboration between players with different learning speeds.

The second game was a quiz game on the lecture Patterns in Software Engineering. In an experimental study with over 300 students we evaluated the motivational leaderboard pattern (Section 4.3). The experiment showed that after five matches students who were compared with a motivational leaderboard that showed other students with similar performance instead of a more classical top ten were more motivated. This could be seen in an increased play time by almost 50%. In the group of students that played over ten matches the effect was even bigger. There the play time was around 70% higher in the group that was shown the motivational leaderboard.

While play time was one interesting aspect, we were even more interested in performance. What we found is that students who were shown a motivational leaderboard also performed better. They answered more accurately and more quickly than their comparison group. This indicates a higher level of concentration. As the ultimate goal of serious games is not simply fun, but learning, this result supports that looking out for good ways to include social interactions is worth it.

As the effect of each pattern depends on the context it is applied in, we then developed a conceptual framework that helps serious game designers to evaluate the serious game pattern within their own game.

We do not view the list of patterns presented here as exhaustive. They rather provide a starting point to deeper thinking about ways to improve serious game

design. Hence we provide a pattern schema that adapts existing pattern templates to fit for serious games, which can be used to develop additional patterns (Section 3.3).

The patterns in this dissertation were deducted from an analysis of existing successful serious games and computer games, as well as existing related pattern catalogues. While this helps with identifying relevant patterns, this does not give sufficient information to how helpful the pattern will actually be. For this dissertation we exemplarily evaluated two patterns. One within a case study, the other within an experimental study. In order to solidify the pattern catalogue more evaluations within different games, contexts, and for different target groups would be interesting.

Appendices

Appendix A

Publications

This is the list of research publications made during the course of this dissertation:

- Experiences from an Experiential Learning Course on Games Development
  Stephan Krusche, Barbara Reichart, Paul Tolstoi and Bernd Brügge
  Proceedings of the 47th ACM Technical Symposium on Computing Science Education, 2016, pp. 582-587.

- Serious Game Patterns for Social Interactions
  Barbara Reichart and Bernd Brügge
  GET 2015 - IADIS Game and Entertainment Technologies, 2015.

- Social Interaction Patterns for Learning in Serious Games
  Barbara Reichart and Bernd Brügge
  EuroPLoP '14 Proceedings of the 19th European Conference on Pattern Languages of Programs, 2014.

- Chemimon - Serious Game for Learning the Basic Chemical Reaction Principles
  Hubert Niedermaier, Eisgruber Ludwig, Reichart Barbara
  GET 2013 - IADIS Game and Entertainment Technologies, München, 2013.

- Teaching Basic Software Engineering to Senior High School Students
  Barbara Köhler, Michaela Gluchow and Bernd Brügge
  Information Systems and Technology for Organizations in a Networked Society, May 2013, pp. 149-165.

- Adaptive Serious Game Development
  Damir Ismailović, Barbara Köhler, Juan Haladjian, Dennis Pagano and Bernd Brügge
  The 2nd International Workshop on Games and Software Engineering (GAS 2012), Zurich, Switzerland, June 2012.

- A Framework for Game Tuning
  Juan Haladjian, Frank Ziegler, Blagina Simeonova, Barbara Köhler, Paul Muntean, Damir Ismailović and Bernd Brügge
  GET 2012 - IADIS Game and Entertainment Technologies, Lisbon, Portugal, July 2012.

- A Quick Prototyping Framework for Adaptive Serious Games with 2D Physics on Mobile Touch Devices
  Juan Haladjian, Damir Ismailović, Barbara Köhler and Bernd Brügge
  IADIS Mobile Learning 2012 (ML 2012), Berlin, 2012.

- Feedback in low vs. high fidelity visuals for game prototypes
  Barbara Köhler, Juan Haladjian, Blagina Simeonova, Damir Ismailović and Bernd Brügge
  2012 Second International Workshop on Games and Software Engineering: Realizing User Engagement with Game Engineering Techniques (GAS), June 2012, pp. 42-47.

- Towards a Conceptual Model for Adaptivity in Serious Games
  Damir Ismailović, Barbara Köhler, Juan Haladjian, Dennis Pagano and Bernd Brügge
  IADIS International Conference - Game and Entertainment, Lisbon, Portugal, 2012.

- The Square Dance Framework - A Framework Approach for module-based Serious Games
  Alexander Waldmann, Damir Ismailović , Juan Haladjian, Barbara Köhler, Bernd Brügge
  IADIS International Conference - Game and Entertainment, 2012.

- Adaptivity in Story-Driven Serious Games
  Barbara Köhler, Damir Ismailović and Bernd Brügge
  IADIS International Conference - Game and Entertainment, Rome, Italy, 2011.

- A Serious Game: WeMakeWords From Developer Perspective and from Psychological Perspective
  Ruth Demmel, Barbara Köhler, Stephan Krusche and Ludwig Schubert
  SPLASH/Onward!, 2011, pp. 109-110.

Appendix B

Evaluation Materials and Data

B.1 School Survey

This is the first iteration of the questionnaire used in schools. It asks students about demographic data, their attitude towards games and serious games, and the availability of electronics.

- What class are you in?
- What is your gender?
- What are your three favorite games?
- Do you prefer to play alone, with or against others?
- Would you play a game that helps you learn for school?
- Do you know a serious game for learning that you like?
- What is your favorite subject?
- In what subject do you struggle the most?
- What topic do you still not fully understand?
- Do you have a smart phone, tablet or computer?
- Did your parents buy serious games for you?
- If yes, did you play them?
- Do you have any topics that you would like to practice with a game?

In the second iteration we added three more questions to the questionnaire on how often students played, for how long and where. Additionally we asked more specifically, what kind of devices they owned. These are the newly added questions:

- How often do you play games?
  - Daily
  - Several times a week
  - Several times a month
  - Less
- How long do you play?
  - For hours
  - Maximally 1 hour
  - A few minutes
- Where do you play mainly?
  - At home
  - On the go
  - At a friends place
- What device do you have?
  - A smartphone: iPhone, Android, or other
  - Tablet
  - Computer

B.2 Questionnaire for evaluating mood after game play

For the evaluation of the motivational leaderboard the short version of the GEQ was used(IJsselsteijn et al., 2008). The questionnaire originally consists of fourteen items, that ask about feelings of competence, challenge, flow, tension, immersion, positive affect, and negative affect. For reference we put the matching feeling in parenthesis. These were not visible to the study participants. Each question could be answered in five ways: not at all, slightly, moderately, fairly, extremely. As they did not fit the quiz game, we left out the questions on immersion, leading to the following questionnaire:

- I felt successful (Competence)
- I felt bored (Negative affect)
- I forgot everything around me (Flow)
- I felt frustrated (Tension)
- I found it tiresome (Negative affect)
- I felt irritable (Tension)
- I felt skillful (Competence)
- I felt completely absorbed (Flow)
- I felt content (Positive affect)
- I felt challenged (Challenge)
- I had to put a lot of effort into it (Challenge)
- I felt good (Positive affect)

Appendix C

Game Pattern Synopsis

Name	Problem	Solution
	Collaboration	
Complimentary Roles	The content is too complex to keep all of it in mind at once.	Split the content up into distinct roles, that collaborate towards a goal. Players can switch roles to experience different aspects of the content.
Scarce Resources	Players do not collaborate, even though it would be possible within the game.	Limiting resources like time, materials, information and space to encourage players to collaborate, offering possibilities to trade.
Synchronization Point	everything is stupid	everything is awesome
Team Allocation	Teams form around circles of friends with similar knowledge, limiting learning opportunities.	The game takes over matchmaking to create more diverse teams.

Competition		
Motivational Leaderboard	Leaderboards with extremely high scores are demotivating especially to beginners.	Only show parts of the leaderboard, either focused on the player himself, or on constraints like time, location and acquaintance.
Player Ranking	Matches between experienced players and beginners are demotivating to both sides.	Creation of fair matches, by calculating an internal ranking for players.
Handycap	There are not enough players to create a fair match.	The playing field can be leveled by giving additional resources to the less experienced player.
Collaboration and Competition		
Mutual Goal	The game should be competitive for experienced players, while it still welcomes newer players in a collaborative way.	Goals that several players can only to achieve together.
Team Competition	Keep information sharing, while having the excitement of competition.	Teams compete against each other. Information sharing happens within a team.

Appendix D

Overview over Pattern Templates

Templates are important to writing a pattern. "The template assures that important questions are answered about each pattern in a pattern language, pattern catalog, or pattern system. Without a template a pattern is just somebody's unstructured prose, or someone saying, "It's a pattern because I'm an expert and I say so." (William J. Brown et al., 1998, p. 49) This is a reference point of some of the most common pattern templates.

D.1 Alexanderian Form

The template consists of three sections: name, problem, and solution. Commonly each section is separated by an asterisk. The word **therefore** is used to indicate the start of a solution.

D.2 Micro-Pattern Template

As the name says, this is the minimal structure expected from a pattern.

Name:
Problem:
Solution:

D.3 Mini-Pattern Template

In a Mini-Pattern Template the solution is broken down further into context and forces, and benefits and consequences. Those sections help in answering the why-questions and hence indicate when to use a pattern.

D.3.1 Mini-Pattern

This form focuses on the applicability of the pattern.

Name:
Context:
Forces:
Solution:

D.3.2 Deductive Mini-Pattern

This form focuses on the outcomes of the solution.

Name:
Problem:
Solution:
Benefits:
Consequences:

D.4 Formal Templates

D.4.1 Gang-of-Four Pattern

This template focuses on micro-architecture-level patterns.(Gamma et al., 2005)

Pattern Name and Classification: The name of the pattern conveying its essence.

Intent: A short statement, describing what the pattern does.

Also Known As: Other well-known names for the pattern.

Motivation: A scenario that illustrates a design problem and how the class and object structures in the pattern solve the problem.

Applicability: The situation in which the design pattern can be applied.

Structure: A graphical representation of the classes in the pattern using a notation based on the Object Modeling Technique (OMT).

Participants: The classes and/or objects participating in the design pattern and their responsibilities.

Collaborations: How the participants collaborate to carry out their responsibilities.

Consequences: Results of using the pattern and possible trade-offs.

Implementation: Pitfalls, hints, or techniques to be aware of when implementing the pattern.

Sample Code: Code fragments that illustrate how to implement the pattern.

Known Uses: Examples of the pattern found in real systems.

Related patterns: Closely related patterns and their differences to this pattern.

D.4.2 System of Patterns Template

Buschmann et al. (1996, p. 19, 20) describes patterns uniformly, to make them comparable. He states this makes it easier to look for alternative solutions to a problem. He formalizes and expands the basic Context-Problem-Solution structure as follows:

Name: The name and a short summary of the pattern.

Also Known As: Other names for the pattern. If any are known.

Example: A real-world example demonstrating the existence of the problem and the need for the pattern.

Context: The situations in which the pattern may apply.

Problem: The problem the pattern addresses, including a discussion of its associated forces.

Solution: The fundamental solution principle underlying the pattern.

Structure: A detailed specification of the structural aspects of the pattern.

Dynamics: Typical scenarios describing the run-time behavior of the pattern.

Implementation: Guidelines for implementing the pattern.

Example Resolved: Discussion of any important aspects for resolving the example.

Variants: A brief description of variants or specializations of a pattern.

Known Uses: Examples of the use of the pattern, taken from existing systems.

Consequences: The benefits the pattern provides, and any potential liabilities.

See Also: References to patterns that solve similar problems, and to patterns that help us refine the pattern we are describing.

Antipatterns Template

The full Antipattern Template can be used to fully document AntiPatterns. The core sections are *general form* and *refactored solution.*(William J. Brown et al., 1998, p. 57).

Antipattern Names:
Also Known As:
Most Frequent Scale:
Refactored Solution Name:
Refactored Solution Type:
Root Causes:
Unbalanced Forces:
Anecdotal Evidence:
Background:
General Form of this AntiPattern:
Symptoms and Consequences:
Typical Causes:
Known Exceptions:
Refactored Solutions:
Variations:
Example:
Related Solution:
Applicability to Other Viewpoints and Scales:

Appendix E

Existing Game Research Questionnaires

Questionnaires measuring user engagement whilst playing digital games. Based on Nordin et al. (2014). A good questionnaire must be **reliable** (individual differences in scores are attributable to true differences in the characteristics under consideration rather than resulting from errors due to random fluctuations in individuals or in testing conditions(Witmer and Singer, 1998; Anastasi and Urbina, 1997)) and **valid** (measures precisely what it purports to measure and measures it well(Witmer and Singer, 1998)).

E.1 Overview

Questionnaire	**Components**
Flow Questionnaire (Csikszentmihalyi, 1998)	Clear Goals
	High concentration
	Reduces self-consciousness
	Distorted sense of time
	Direct and immediate feedback
	Balance between ability level and challenge
	A sense of personal control
	Intrinsically rewarding activity
Presence Questionnaire (Witmer and Singer, 1998)	Control factor
	Sensory factor
	Distraction
	Realism factor

Questionnaire	Components
Immersive Experience Questionnaire (IEQ) (Jennett et al., 2008)	Emotional involvement Cognitive involvement Real world dissociation Challenge Control
GameFlow Questionnaire (Sweetser and Wyeth, 2005)	Concentration A sense of challenge Player skills Control Clear goals Feedback Social interaction Immersion
Game Engagement Questionnaire (GEQ) (Brockmyer et al., 2009)	Absorption Flow Presence Immersion
Player Experience of Needs Satisfaction (PENS) (Ryan et al., 2006)	Competence Autonomy Relatedness Presence (Immersion)
Social Presence in Gaming Questionnaire (SPQG) (de Kort et al., 2007)	Psychological involvement (empathy) Psychological involvement (negative feelings) Behavioral engagement

E.2 Presence Questionnaire

(Witmer and Singer, 1998)

1. Do you ever get extremely involved in projects that are assigned to you by your boss or your instructor, to the exclusion of other tasks?

2. How easily can you switch your attention from the task in which you are currently involved to a new task?

3. How frequently do you get emotionally involved (angry, sad, or happy) in the news stories that you read or hear?

4. How well do you feel today?

5. Do you easily become deeply involved in movies or TV dramas?

6. Do you ever become so involved in a television program or book that people have problems getting your attention?

7. How mentally alert do you feel at the present time?

8. Do you ever become so involved in a movie that you are not aware of things happening around you?

9. How frequently do you find yourself closely identifying with the characters in a storyline?

10. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?

11. On average, how many books do you read for enjoyment in a month?

12. What kind of books do you read most frequently? Spy novels Adventure Westerns Biographies Fantasies Romance novels Mysteries Science fiction Historical novels Other fiction Other non-fiction Autobiographies

13. How physically fit do you feel today?

14. How good are you at blocking out external distractions when you are involved in something?

15. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?

16. Do you ever become so involved in a daydream that you are not aware of things happening around you?

17. Do you ever have dreams that are so real that you feel disoriented when you awake?

18. When playing sports, do you become so involved in the game that you lose track of time?

19. Are you easily disturbed when working on a task?

20. How well do you concentrate on enjoyable activities?

21. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

22. How well do you concentrate on disagreeable tasks?

23. Have you ever gotten excited during a chase or fight scene on TV or in the movies?
24. To what extent have you dwelled on personal problems in the last 48 hours?
25. Have you ever gotten scared by something happening on a TV show or in a movie?
26. Have you ever remained apprehensive or fearful long after watching a scary movie?
27. Do you ever avoid carnival or fairground rides because they are too scary?
28. How frequently do you watch TV soap operas or docu-dramas?
29. Do you ever become so involved in doing something that you lose all track of time?

E.3 Immersion Questionnaire

Players were asked to rate how far they would agree with each statement below after playing the game. They could answer on a five point Likert scale. Answers were: strongly disagree, disagree, neutral, agree, and strongly agree.

- I felt that I really empathized/felt for with the game.
- I did not feel any emotional attachment to the game.
- I was interested in seeing how the games events would progress.
- It did not interest me to know what would happen next in the game.
- I was in suspense about whether I would win or lose the game.
- I was not concerned about whether I would win or lose the game.
- I sometimes found myself to become so involved with the game that I wanted to speak to the game directly.
- I did not find myself to become so caught up with the game that I wanted to speak to directly to the game.
- I enjoyed the graphics and imagery of the game.
- I did not like the graphics and imagery of the game.

- I enjoyed playing the game.
- Playing the game was not fun.
- The controls were not easy to pick up.
- There were not any particularly frustrating aspects of the controls to get the hang of.
- I became unaware that I was even using any controls.
- The controls were not invisible to me.
- I felt myself to be directly traveling through the game according to my own volition.
- I did not feel as if I was moving through the game according to my own will.
- It was as if I could interact with the world of the game as if I was in the real world.
- Interacting with the world of the game did not feel as real to me as it would be in the real world.
- I was unaware of what was happening around me.
- I was aware of surroundings.
- I felt detached from the outside world.
- I still felt attached to the real world.
- At the time the game was my only concern.
- Everyday thoughts and concerns were still very much on my mind.
- I did not feel the urge at any point to stop playing and see what was going on around me.
- I was interested to know what might be happening around me.
- I did not feel like I was in the real world but the game world.
- I still felt as if I was in the real world whilst playing.
- To me it felt like only a very short amount of time had passed.

- When playing the game time appeared to go by very slowly.
- How immersed did you feel? (10 = very immersed; 0 = not at all immersed)
  1 2 3 4 5 6 7 8 9 10

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