Generation of Effective Serious Games with Static and Dynamic Content

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Dipl.-Inf. Philip Mildner
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Dekan:	Professor Dr. Heinz Jürgen Müller, Universität Mannheim
Referent:	Professor Dr. Wolfgang Effelsberg, Universität Mannheim
Korreferent:	Professor Dr. Maximilian Eibl, Technische Universität Chemnitz

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Abstract

With video games being a huge market, attracting and engaging millions of players, it is tempting to use these motivational aspects not just for entertainment. After all, play as the basis of games has inherent learning aspects, for example seen at the way how children play and learn. The serious games movement that took off at the beginning of the 21st century wants to achieve exactly that: provide playful learning environments and utilize the motivational aspects of games to transport serious content to players. Getting from such an idea to an actual game, however, is far from trivial. A fundamental problem is how to integrate serious content and game parts. Finding ways how to improve the game creation process to produce applications that are both fun to play and effective in delivering a serious content is the main focus of this thesis. Therefore, the problem is approached in two ways: by providing best practice tips for the creators of serious games and by presenting results of different practical game implementations and studies.

Two sets of serious games — seven in total — have been developed within the course of this thesis. The first set comprises games with static serious content. These games depict the regular development approach. Here, a static game concept is created and implemented by professional game developers. This approach allows for a high degree of freedom in the game creation process. Nevertheless, emphasis has to be put on combining serious content in the right way to produce effective and fun serious games. Best practice tips are given along with presenting results from user studies that are based on the implemented game prototypes. The second set of games features dynamic learning content. In contrast to static variants, these games support changing the learning content at runtime. This allows for more accessible creation methods: Once created, any domain expert can create own custom games without the need for expertise in game development. On the other hand, special emphasis has to be put on designing the frameworks in a manner that game scenario and learning content are well integrated, despite not having a thematic connection. Different approaches are examined by developing games with dynamic content. The games are evaluated in terms of their usefulness. Different user studies look at the motivational aspects as well as at the learning outcome. Furthermore, the effect of not having a connection between game scenario and learning content is examined to compare the effectiveness of static and dynamic variants.

Zusammenfassung

Videospiele haben sich zu einem Massenmedium entwickelt, das täglich Millionen von Spielern anzieht und begeistert. Dadurch wird die Nutzung dieser motivierenden Elemente für Zwecke interessant, die nicht nur der puren Unterhaltung dienen. Nicht zuletzt beinhaltet das Spielen inhärente Lernaspekte, die zum Beispiel beobachtet werden können, wenn Kinder spielend lernen. Die zur Jahrtausendwende aufgekommene *Serious Games*-Bewegung hat genau dies zum Ziel: spielerische Lernumgebungen bereitzustellen, bei denen die motivierenden Elemente von Spielen genutzt werden, um Lerninhalte oder weitere Konzepte an Spieler zu vermitteln. Von der ersten Idee bis zum fertigen Spiel zu gelangen, ist allerdings eine sehr komplexe Aufgabe. Ein grundsätzliches Problem hierbei ist es, Lern- und Spielinhalte auf sinnvolle Weise miteinander zu kombinieren. Der Hauptaspekt dieser Arbeit liegt deshalb auf der Verbesserung des Spielerstellungsprozesses mit dem Ziel, Anwendungen zu kreieren, die sowohl Spaß machen als auch effektiv das jeweils integrierte Konzept vermitteln. Diese Problemstellung wird in zweierlei Herangehensweisen bearbeitet: Zum einen stellt die Arbeit theoretisch fundierte Tipps und Lösungsstrategien für Spieledesigner bereit. Zum anderen werden die Ergebnisse von verschiedenen praktischen Spieleimplementierungen und Ergebnisse von durchgeführten Studien präsentiert.

Insgesamt wurden sieben Spiele implementiert und evaluiert. Die erste Kategorie besteht aus Spielen mit einen statischen Lerninhalt. Dies stellt die herkömmliche Weise der Spieleherstellung dar. Dabei wird ein Spielkonzept für einen bestimmten Lerninhalt erarbeitet und dann von professionellen Spieleentwicklern umgesetzt. Diese Herangehensweise ermöglicht es, maßgeschneiderte Spiele mit maximaler Freiheit in der Erstellungsphase zu erschaffen. Allerdings muss dabei besonderes Augenmerk auf eine sinnvolle Integration von Spiel- und Lerninhalt gelegt werden. Dafür werden im Rahmen der Arbeit relevante Themen erörtert und praktische Tipps für Spieledesigner präsentiert. Als zweites werden Spiele untersucht, die die Einbettung von Lerninhalten zur Laufzeit unterstützen. Dies macht den Erstellungsprozess zugänglicher, da es Personen ohne besondere Spieleentwicklungskenntnisse erlaubt, selbst Spielrunden zu beliebigen Themen zu erstellen. Auch hier muss das Anwendungskonzept entsprechend optimiert sein, um auch mit generischen Lerninhalten ein unterhaltsames und effektives Spiel bereitzustellen. Erschwerend kommt dabei hinzu, dass es nicht zwingenderweise eine Verbindung von Spielmechaniken zu Lerninhalten gibt. Zur genaueren Untersuchung dieser Aspekte werden verschiedene Herangehensweisen untersucht und praktisch umgesetzt. Diese Spiele werden hinsichtlich ihrer Wirksamkeit durch Nutzerstudien untersucht. Abschließend werden zudem die Effekte untersucht, die durch die Entkopplung von Spiel- und Lerninhalten entstehen, um die Effektivität von statischen und dynamischen Spielen miteinander zu vergleichen.

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Allen voran gilt mein Dank meinem Doktorvater Professor Dr. Wolfgang Effelsberg, dem ich die Möglichkeit zur Promotion am Lehrstuhl „PI4“ zu verdanken habe. Während meiner gesamten Promotionszeit war Professor Effelsberg mit großem Engagement und guten Ratschlägen zur Stelle und hat so maßgeblich zum Fortschritt meiner Arbeit beigetragen. Professor Dr. Heinz Jürgen Müller möchte ich für sein Interesse an Serious Games danken und dafür, dass er sich stets für das Bekanntwerden dieses Themas eingesetzt hat. Aus seiner Initiative heraus sind spannende Projekte entstanden, deren Ergebnisse mit in diese Dissertation eingeflossen sind. Professor Dr. Maximilian Eibl danke ich für die Übernahme des Korreferats. Außerdem möchte ich mich bei allen Projektpartnern bedanken. Die Zusammenarbeit war immer fruchtbar und gab mir die Möglichkeit, Anwendungen jenseits des „Elfenbeinturms“ zu entwickeln.

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All den Genannten und auch den nicht explizit Erwähnten möchte ich noch einmal sagen: Vielen Dank!

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Acronyms

AI artificial intelligence. 63

API application programming interface. 115, 126, 129, 243

CET cue-exposure based extinction training. 111, 112, 117, 118

CMS construction and management simulation. 21, 101, 102, 104, 167, 239

COTS commercial of the shelf. 73, 74, 102, 130

DGBL digital game-based learning. 39

ESA Entertainment Software Association. 22, 33

FPS first person shooter. 24, 41, 72, 130, 131, 143, 159, 161, 169, 235, 236, 239, 242, 244

GBL game-based learning. 39

GUI graphical user interface. 70, 107, 137, 141, 144

HTB Hit the Buzzword. 154, 155

IDE integrated development environment. 241, 242

JSON JavaScript Object Notation. 153–155, 159

MMOG massively multiplayer online game. 45

MMORPG massively multiplayer online role playing game. 15, 31, 33, 240

MUD multi-user dungeon. 31, 33

MVC model view controller. 242, 243

NFC near-field communication. 129

NPC non-player character. 29, 31, 32, 62

RPG role-playing game. 20, 21, 30, 58, 71, 243

RTS real-time strategy. 20, 27, 55, 104, 150, 235

UI user interface. 65, 70

VR virtual reality. 20, 243

ZI Zentralinstitut für Seelische Gesundheit (Central Instititute for Mental Health) Mannheim. 111, 112, 116

1. Introduction

Video games have become one of the most popular pastime activities. Each day, they engage millions of players with their interactive stories that set them apart from static media such as movies. Players are being drawn into fantasy worlds, and large social communities are formed in online games. Games motivate by always posing new challenges to players that are to be solved. In order to provide the latest graphics style and complex game mechanics, the game industry is one of the driving factors for developing more powerful hardware. With this trend, serious games are getting more popular, too. The purpose of these games is not only to entertain players, but to teach, train or to transport some kind of serious content. Despite the popularity of today's video games, however, the mere act of playing is seen controversial. Concerns are being raised about players getting socially isolated. When played excessively, games can cause addictions, and they are held responsible for facilitating violent behavior. Moreover, the act of playing games itself is often seen as a leisure activity with no real benefits. Following this thought, games could even be seen as a waste of time that could be spent better doing more important things. Using games for serious purposes then seems impossible since both concepts are directly contrary to each other. Opposed to this view stands an increasing availability of serious games that proved to be effective, leaving the question how the concept of combining game and serious content can work best.

While the modern serious games movement is a quite recent trend dating back to the 1970s, the basic concept is much older. It begins at the origin of all games, that is play. Play is an inherent and pure form of learning used by humans as well as by animals since thousand of years. It allows players to immerse into an isolated space where real-world rules are suspended to train actions and situations without having to fear serious consequences. Playing is thereby driven by an inner motivation. Games take up on these aspects. They give play structure, add rules and goals to it and define start and end. What is true for play, however, is also true for games: They are played out of free will and with intrinsic motivation. Then again, the reasons why games are played and how they raise this motivation in players are manifold. A lot of aspects are responsible for creating engagement in players. Since there are different personalities, not all players are fascinated by the same mechanics. Some are driven by competition, others by social factors. Other kinds of players simply enjoy exploring the virtual game world or following the stories that games tell. It is these motivational aspects that are utilized by serious games. While they were originally used in educational settings almost exclusively, serious games have spread to further application fields, including the health sector, corporate applications, the

military sector — including *America's Army*[1], considered to be the first largely successful serious game — and social areas such as journalism.

1.1. Motivation

Serious games should be fun, just like regular entertainment games. In addition to that, they are also intended to transport some kind of serious content to players — for example learning a foreign language or promoting physical exercises. When looking at the development of serious games, a main part — maybe even the most important one — is how to combine serious content and game parts. This task is far from trivial, and is not done by just plugging the serious content into an existing game. Some forms of serious content are suited for creating intrinsic serious games where both contents are one and the same. A popular example are flight simulators. Game mechanics and learning goal overlap here since both are the same action, namely flying an airplane. Other serious games work in an extrinsic manner where serious content is integrated into games with other forms of game mechanics. Independent of the form of serious game, the interleaving of serious content and game parts has to be done correctly in order to create games that are both fun and effective with regard to their purposes. If done wrong, the result will either be boring, or it will not transport the serious content correctly, for example by posing a distraction from it. Edutainment — nowadays considered a failed experiment — is one of those negative examples. Consequently, a lot of work has to be put into each new game to come up with an appropriate concept and an appealing implementation.

While there are serious games available for all kinds of purposes, a common strategy how to create good serious games does not exist yet. Consequently, the following research question has been identified as a central focus for this thesis:

> *When creating serious games, in what way should serious content and game parts be combined so that the result is both fun and effective in transporting the serious content to players?*

The design considerations of serious games take a main part in answering this question. At first view, the process of designing serious games does not differ much from the one used for creating pure entertainment games. Many techniques can be used in both forms of games since they share many characteristics. The main difference — and also the biggest challenge — is how to turn serious content into specific game mechanics. It starts with specifying the goals and the intended usage scenario of a game as exactly as possible. In further steps, games have to be tailored towards certain target groups, ideally without excluding others. Only when all main specifications are set should the actual development of a game start.

The design and development of serious games is a complex task on its own, but too often it gets more complicated due to missing resources. Almost every game development process — including entertainment and serious games — has to cope with limited budgets.

[1] This thesis includes a list of referenced games — both entertainment and serious games — in a dedicated glossary (starting on Page 235). Consequently, not all games are explained in detail in the main document.

These manifest in a restricted development time for game studios or simply the lack of professional game development knowledge in smaller projects. Serious game development increases such bottlenecks even further because it brings another stakeholder into the process, namely the domain experts for the serious content. Transferring knowledge between domain experts and game developers in an efficient manner poses a crucial challenge in improving the development of serious games. A commonly used approach to achieve this transfer is the use of authoring tools. They provide abstraction levels and simplified interfaces, allowing non-professional game developers to create custom games without the need of programming or even designing the game parts. However, the idea that every teacher or instructor can conveniently create own games by simply entering learning content and then letting the authoring tool create a matching game has remained a vision so far. Such tools would greatly improve the applicability of serious games since the creation process gets more accessible, and more games for different scenarios can be created. Looking back at the formulated research question above, the scope is therefore extended as follows:

> *How can authoring tools be created that require as little expertise in game development as possible and that still result in fun and effective games for arbitrary serious contents?*

This question builds up on the first one. However, the scope is moved from a manual approach to providing automated tools that take into account the balance between fun and serious content for different kinds of input. A related question is whether a manual approach is always better or if games that were created with authoring tools can compete when it comes to measuring the outcomes of both games. These aspects will be examined in this thesis by providing theoretical background information, by looking at the details of game development methods, and by performing evaluations with games of both types.

1.2. Outline of the Thesis

This thesis is divided into three main parts that follow the approach presented above, namely presenting relevant background information, evaluating possibilities for the design and development of serious games and presenting concrete results of different implemented games.

Part I provides the basis for all following content by providing background information with a theoretical focus. At first, the concept of play is presented in Chapter 2. After looking at the definition and origin of the term, its relevance to learning aspects and today's work life are examined. Chapter 3 builds up on this and presents the theoretical foundations of games by defining the term and listing the basic elements that all games share. A special focus is put on digital games since all games that are covered in this thesis are of this form. The motivational aspects of them, including the important concept of *flow*, are presented as well as how they engage different types of players. Chapter 4 then gives an introduction into serious games. A possible definition is given by looking at the history of serious games and the different perspectives on how they have been perceived

until today. Related terms are presented as well as commonly seen receptions of games with regard to their applicability to serious purposes. Part I then closes with an overview of the main application areas of serious games. It concentrates on educational games since they also build the main object of study in this thesis.

Part II moves the focus from theory to praxis by presenting creation methods for serious games. This process starts with Chapter 5 that deals with design considerations. They build up on commonly used techniques from entertainment game design but lay emphasis on the integration of the serious content and the game parts. This starts at the very beginning of the design phase by selecting a game scenario and by defining goals, target group and intended usage scenarios. Subsequently, game mechanics can be added to the initial idea. A selection of possible elements are presented and enriched with practical examples. The following Chapter 6 gives insights on the next step in the game creation process: the implementation phase. Developers can decide between a range of different tools and technologies to use that differ in complexity levels and degree of freedom. This ranges from full fledged game engines to specialized authoring tools that do not require expert knowledge. Representative samples of all kinds of game creation tools — from engines for generic entertainment games up to specialized authoring tools for serious games — are presented and categorized to give an overview. Chapter 7 puts the presented approaches of Chapters 5 and 6 into use by presenting a case study. Using the example of a simple quiz game, the study examines what game elements should be picked for a game if a limited budget is available. Different elements are added to the game and evaluated concerning their effects on maximizing fun and learning effect.

Part III presents the results of projects and studies that have been carried out in the scope of this thesis. Several games have been developed that can coarsely be fit into two categories. Chapter 8 contains all games that feature a static serious content whereas games that are equipped with dynamic serious content are presented in Chapter 9. This distinction refers to the accessibility of integrating new serious content: Static games can only be enhanced with an implementation effort. Once published, there is no possibility for end users to change these games. Dynamic games, on the other hand, allow the manipulation of serious content during runtime of the game by providing some kind of authoring tool. Some of the games have been created in collaboration with external partners while the others originated out of a specific research question. In total, seven games were developed that will be briefly explained in the following:

Professor Architecto's Quest A learning game about the topic of architecture targeted towards young students. It follows a story-driven approach where different aspects of architecture are presented to players. It was created in collaboration with an architect for use in classroom scenarios. Presented in Section 8.1.

Corruptica An educational game that includes aspects of business ethics. Based on common business simulation games, players are confronted with ethical decisions in the role of a manager of a textile company. The game falls into the category of newsgames. It originated out of a collaboration with a domain expert for use in educational settings. Presented in Section 8.2.

A Training Game for Alcohol-Addicted Patients This game in the health sector was created to accompany therapy of alcohol-addicted patients. Players are put into situations where they are normally confronted with alcohol in their real lives. The goal is to consciously train not to choose alcohol when there is a choice. This game was created with external partners as well. Presented in Section 8.3.

LibChase A mobile, location-based learning game. Its intended usage is to teach students the services of university libraries. The game has a strong focus on real-world tasks and works with game elements often found in gamification applications. It was created in collaboration with a university library and features authoring components. Presented in Section 9.1.

Word Domination A mix of fast-paced multiplayer action game and quiz application. The game was created out of the idea of having an entertaining game that can be used with arbitrary learning content by providing authoring capabilities. As a central object of research, it was evaluated and presented in various scenarios. Presented in Section 9.2.

The Mannheim Game An educational game that teaches the history of the city Mannheim to middle and high school students by letting players reenact a spy thriller at the end of the 18th century based on historical facts. The learning aspects consist of the realistic representation of the historical sights and of quiz questions regarding the city's history. Presented in Section 9.3.

Knowledge Defence Originated as a successor of *Word Domination*. It features a tower defense game that is supplemented by learning content. An authoring tool allows not only to add new learning content but also new types of it. Therefore, custom mini games can be added with little development effort. Presented in Section 9.4.

Part III concludes with an analysis about the factor of game world coherence — that is, how much learning content and game world match — on fun and learning effect. The study along with an adapted version of *Word Domination* is presented in Chapter 10. The thesis closes with a summary and an outlook to further developments in Chapter 11.

Part I.

Theory of Play, Games and Serious Games

2. Play

Digital games have become an integral part of modern culture and are on the way to outpace movies in terms of budget and audience (Siwek, 2014). With that trend, digital *serious* games also gain more attention. Looking at the history of games in general, however, such games have only a very small part. Before there were modern digital games, non-digital games have existed for centuries. And even before there were games with distinct names and rules, there was play in its pure form. But what exactly do these terms mean and how are they related? In order to fully understand the concepts of modern serious games, it is important to start at the very beginning. This chapter thus deals with the topics of *play* and *games*. After a definition of the terms, relevant concepts are presented. With its theoretical focus, this chapter acts as a basis for the following parts.

2.1. Definition

While the activity of playing is commonly known and understood, it is hard to find a universal and precise definition. There is a multitude of definitions in dictionaries and in the literature, but for a long time there were no definitions that were widely accepted. A reason for this is that the concept of play is so basic and natural that it is hard to exactly explain what it is. Play can of course be found with humans, but it can also be observed with a lot of animal species. Then again, there are wide cultural differences how play is perceived in different cultures and ethnic groups. What all these different forms share, however, is a set of common characteristics. These will be presented — along with the most common definitions — in this section.

There is not only one definition of play. According to existing literature, the definition of play includes keywords such as *fun* (LeCompte, 1980, p. 123; Statler et al., 2011), *active, spontaneous and free* (Adams, 2010, p. 4; Huizinga, 1955), *recreational* (Adams, 2010, p. 4), *socially significant* (Adams, 2010, p. 4; Statler et al., 2011) or *intrinsically motivated* (Statler et al., 2011; Fein and Wiltz, 1998, p. 46). Starbuck and Webster (1991) even narrow the definition down to two components: involvement and intrinsic pleasure — any feature that is added to these components would make play either very rare or very diverse. What many of these aspects have in common is that play is mostly seen as neither serious nor productive, deeming it a leisure time activity (Brezinka et al., 2007). While the former is generally true, saying that play is not serious in its nature or anything meaningful is not right. This is a first important characteristic of play: While it is a free activity performed in leisure time, its intentions can very well be serious. What sounds like a contradiction has been intensively studied over time. Huizinga and Caillois are well-known foundational theorists in the field of ludology, the studies of games in culture. Both studied the concept and function of play over the history of humans. Specifically its relation to culture were

a main interest to both authors. According to Huizinga, humans develop their roles in culture and society by playing. Play also enables humans to discover themselves and to develop their cognitive abilities, and thus can be regarded as *"an active form of learning that unites the mind, body, and spirit"* (Witherspoon and Manning, 2012). Caillois states that play is a fundamental part of human existence, similar to language or arts. This is especially true for children as they get to know their environment and practice for situations they will experience later in life by playing with an inherent ludic drive (Caillois and Barash, 1961; Huizinga, 1955). As a result, play is no longer just a pastime but can be seen as an important psycho-social component of personality development.

In the book *Homo Ludens*, Huizinga (1955) gave the following definition of play that is now frequently used in the literature:

> *"Summing up the formal characteristic of play, we might call it a free activity standing quite consciously outside 'ordinary' life as being 'not serious' but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner. It promotes the formation of social groupings that tend to surround themselves with secrecy and to stress the difference from the common world by disguise or other means."* (Huizinga, 1955)

This definition has been broadly accepted, but some factors of it are still up for discussion. (Caillois and Barash, 1961, p. 7) state that it limits the concept of play to a too narrow space. They agree with the majority of Huizinga's characteristics but argue that there is material interest and there can be profit in play when it comes to gambling, for instance. Consequently, Caillois and Barash use an own definition for the concept of play. They describe it as

> *"a free and voluntary activity that occurs in a pure space, isolated and protected from the rest of life. Play is uncertain, since the outcome may not be foreseen, and it is governed by rules that provide a level playing field for all participants. In its most basic form, play consists of finding a response to the opponent's action — or to the play situation — that is free within the limits set by the rules."* (Caillois and Barash, 1961)

Caillois and Huizinga both have the opinion that the activity of play is valuable for cultural development. Then again, both state that play is *"isolated and protected"* (Huizinga, 1955) or *"standing [...] outside 'ordinary' life"* (Caillois and Barash, 1961), respectively. Following this argumentation, play cannot have a role in the real world, making serious games obsolete altogether. As mentioned above, however, these two constructs are not mutually exclusive. Brezinka et al. (2007) argue that play is able to transfer energy and creativity from playing to the real world and manages to set free powers within players. After all, playful elements are often used in creative arts disciplines because they are able to foster idea generation. Following this idea, Pearce (2006) argues that modern digital games turn customers into producers by letting players create their own game content.

Players might sell cloths they created in *The Sims*, publish videos of their played games, modify game software and hardware or participate in cosplay (costume play) (Klopfer et al., 2009). Malaby (2007) suggests to enhance the traditional definition of play due to the blurred boundaries between modern play and the real world. To his understanding, play can not only be materially productive but it can also have impacts on social and cultural contexts. Lindtner and Dourish (2011), who studied game cultures in China, even state that the productive character of play is not limited to the material, economic or social value generated, but constitutes an important aspect of individual and national identity formation. Such broad definitions of play do not contradict the intention of serious games which, by design, also have a connection to the real world in some way.

2.2. The Magic Circle

Looking back at the core definition of play from Huizinga (1955) and Caillois and Barash (1961), a central concept for both is the *"magic circle"*. It was initially introduced by Huizinga and referred to the spaces where games take place, like basketball courts or stages. The magic circle is not limited to games, however. It can also be applied to temples and actual magic circles that are used for religious rituals (Huizinga, 1955). As such, the term depicts an either physical or virtual space in which an activity takes place that is decoupled from the real world surrounding it (see Fig. 2.1). Rules, ideas and actions can be created within the magic circle that have a different meaning or none at all in the world around it. For example, in a soccer match one player gets the role of the goalkeeper which is allowed to touch the ball with hands while the other players are not. As soon as the match is over, the ball can again be touched by everyone. Adams (2010, p. 5–6) uses the example of a soccer match as well to illustrate the magic circle. He states that pretense is the most important requirement for the magic circle to work. Players leave the real world and its rules behind and create a sphere in which they can experience *"the taboo, the challenging and the passionately desired"* (Dovey and Kennedy, 2006, p. 41).

The magic circle and play as a free activity are closely related. Klopfer et al. (2009) list different types of freedom in play, including the freedom to fail, the freedom to experiment, the freedom to fashion identities, the freedom of effort, and the freedom of interpretation. To their understanding playing is valuable because it lets players experience failures without failing, conduct experiments and invent new approaches, experience different roles and identities, and decide between intense and relaxed play (Klopfer et al., 2009).

The view on play as a free activity in the magic circle lets players test actions and decisions without having to fear severe consequences. This is also a major reason why play is important for serious games. Just like with the definition of play, however, the strict definition of the magic circle is in contradiction of connecting topics from a real-life aspect to a game. For this reason, the magic circle does not solely exist as a non-permeable construct. Even an abstract game like chess can conflict with the real world, for example if it is played via mail and the players can think of the next move during their daily routine (Juul, 2003). Looking at the soccer example from above, the consequences can be more severe, for example if a player gets injured during play. Gambling — which also is a form

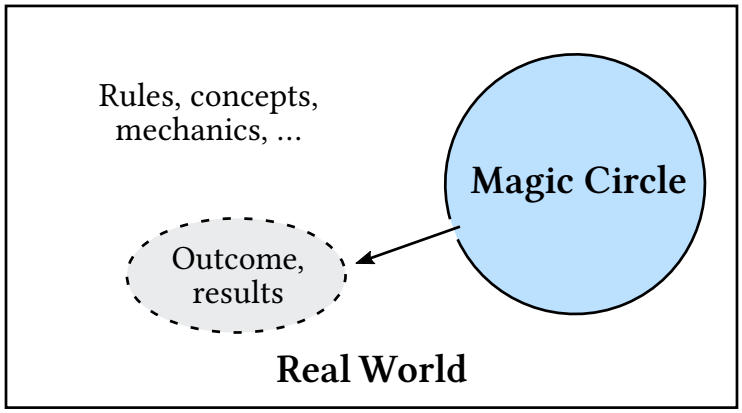


Figure 2.1.: The concept of a "magic circle" allows to create an isolated space where rules and concepts of the real world do not have to apply. However, certain outcomes can be transferred back from the magic circle to the real world.

of play — can even have more dramatic consequences when a player loses a big amount of money (Malaby, 2007). Following this, it is clear that non-digital play can have impacts in the real world, because — even though playing takes place decoupled from real-life rules — it still is located in real world locations. Digital games, on the other hand, are located in a purely virtual environment with normally no connection to the real world whatsoever except for input and output devices. Following this thought, the assumption suggests that the immutable magic circle at least holds true for this kind of games. This is not true, however. Players can be influenced by decisions they made while playing later in their real life and can, like with the chess example, still think about games when not playing. Serious games can use this "leak" in the magic circle deliberately to transport their actual content from the game to the real world. When doing so, they can influence and make a difference to the lives of their players. The basic concept of play being a free activity that allows to experiment without having to fear consequences has to be present in serious games as well, though. The definition of the "magic circle" thus has become somewhat selective. By allowing positive effects — such as learning outcomes — to leave, but at the same time prohibiting realistic consequences from entering, the modern "magic circle" rather resembles a semi-permeable membrane (Castronova, 2007).

2.3. Origin and Cause

While digital games are a very recent invention, play itself is a lot older. In fact, not only humans play but also animals do. This can be observed with all mammals, certain birds and even some reptiles and thus is an evidence that the origins of play date back millions of years and serve an evolutionary purpose (Ohler and Nieding, 2006, p. 102). It gives players — animals or humans — the advantage of preparedness in certain situation while non-players have to face the same situation untrained (Ohler and Nieding, 2006; Prensky,

2007). Another reason for play being so successful is that there usually are no serious consequences in play compared to the real-life situations (Klopfer et al., 2009). This is especially important for children or animal cubs. For example, lion cubs fight playfully to train for more severe fights when they are adult and have to catch prey or protect their territory. Similar processes apply for human children when they learn the alphabet by singing an alphabet song or learn counting by rhymes (Prensky, 2007). In addition to pure learning, children can also train their socio-culturally expected roles as adults (Fein and Wiltz, 1998). Following these concepts, play can be taken as the natural way of learning. Koster (2005) states that by experiencing potentially serious situations in a playful manner, human and animal brains get to train behavior patterns which then also apply in the real situation, because brain patterns in a simulated, pretended situation do not differ from the patterns evoked by the corresponding real situation. He argues that the only difference between play and real life in this context is that a game lowers the stakes and manages to sieve out the essential parts of a problem. This is a perfect argument for serious games, as they can be specifically made to train specific situations or to work on different kinds of problems. Following the argumentation of play being the natural way of learning, serious games thus can be seen as a natural way to transfer knowledge. In this way, the terms *serious* and *play* no longer are an oxymoron but form a logic union as play is both free and serious at the same time.

2.4. Forms

Play itself is a free activity that does not have to follow rules and does not need an immediate goal. The intention to play, however, can have different causes. As such, play can take different forms. A basic form is the one described above, where it is used as a training measure, for example for children, but more forms are possible. Sutton-Smith (2009) created seven so-called rhetorics of play which will be presented in the following.

1. *Rhetoric of play as progress* describes the learning or training purposes of play which can be commonly found in children playing. In addition to cognitive skills, players can also acquire moral and social standards. Play thus serves more as development than as entertainment.

2. *Rhetoric of play as fate* refers to actions that are based on chances, like gambling or lotteries. By relying on chance and the concept of destiny, this form of play does not require much player action, and the outcome can mostly not be influenced.

3. *Rhetoric of play as power* bases around a conflict between different parties. It can be found in many sports games, like in soccer where there is a set of key players that play against each other.

4. *Rhetoric of play as identity* is used to bond or form the identity of a group. Traditionally, it can be found in rituals and celebrations. Play that evolves around forms of collaboration also falls in this category.

5. *Rhetoric of play as the imaginary* is a diverse form of play that includes all aspects of imagination and creativity. Role plays are an obvious application field of this form that *"idealises [...] imagination, flexibility and creativity"* (Dovey and Kennedy, 2006, p. 31).

6. *Rhetoric of the self* refers to the core mechanic of play being an intrinsically motivated activity. Players do not need an external trigger to perform it, but they do it out of an inner curiosity, self realization or just "because it can be done".

7. *Rhetoric of play as the frivolous* has its origins in the middle ages when tricksters or fools playfully mirrored and ridiculed society. Seen as a type of protest, it can also be applied in a similar way nowadays.

The listed forms of play are also relevant for digital games. *Progress* is especially important for serious games that train and educate, as most of the available games do (Dovey and Kennedy, 2006, p. 31; Michael and Chen, 2006). The form of *play as power* is used by digital variants of corresponding games, such as sports games, but it can also be extended to the e-sports movement in which the players themselves act as the key players in the games they play. The other forms of play can be found in digital games as well. For example, *play as self-solitary* is a big factor of digital entertainment games, because they are usually just build to entertain players and to attract various kinds of players (Dovey and Kennedy, 2006, p. 31). All in all, the different forms of play are valid on their own but also build a foundation for different forms of games which include serious games.

2.5. Play and Work

The combination of play and work is a topic that is often discussed controversially. Play is usually connected to terms such as *"fun, enjoyment, game, laughter, [...]"* whereas work is related to *"pressure, boredom, deadlines, chores, [...]"* (Prensky, 2007). According to Starbuck and Webster (1991), this distinction dates back to the age of industrialization where work became socially and spatially separate from non-economic spaces, especially from leisure. They even suggest that it originated much earlier as a separation between social classes: while the upper classes where occupied with painting and writing poetry, lower classes were forced to manual labor. The distinction of both concepts is still present nowadays as play is generally understood as a leisure activity that — by definition — is a contradiction to serious work that people have to do in order to maintain their existence. Play is even seen as a distraction from more important tasks, because it supposedly does not contribute to any productivity (Fritz et al., 2011). This has been especially true for the relatively new discipline of digital play that is not as established as more traditional forms such as card games (Williams, 2006). However, recent studies indicate a slow paradigm change in this regard. Work and play are not longer treated as excluding opposites (Fein and Wiltz, 1998; Yee, 2006a). Statler et al. (2011) note that the only remaining separation between whether a task is work or play is intrinsic motivation. As soon as a task is performed without any extrinsic stimuli, it is not longer seen as work but as play. Dovey and Kennedy (2006) argue that the blending of both concepts works in both directions.

Just as work can incorporate playful elements, games can become work. Both directions are of interest for the area of serious games.

An area where games increasingly interweave with concepts of work are virtual online worlds, namely massively multiplayer online role playing games (MMORPGs) such as *Word of Warcraft*. Several studies have been carried out that examined this trend (Castronova, 2007, 2008; Lastowka and Hunter, 2003; Taylor, 2006). An outcome of them is that virtual worlds have a huge impact on society and culture in general. This follows the extended definition of the magic circle that allows magic circle and reality to interact (Castronova, 2007). One example for this phenomenon is money. Virtual worlds have economies where goods can be created, traded and sold. Some games include the possibility to officially buy such goods for real money by transferring money into an ingame currency. This direction of interaction between the real world and the game is intended, because it creates revenue for the game publisher. However, the other direction is possible as well — even though mostly illegal. If players choose to offer their goods on online auction platforms such as eBay, they are able to make money out of purely virtual goods and turn in-game money into real money again (Schubert, 2007). As such, the virtual economy becomes part of its real-world counterpart (Castronova, 2007, p. 149; Lastowka and Hunter, 2003). This goes even further when a game turns into an income opportunity for unemployed workers who earn their income by trading virtual goods (Castronova, 2007; Lastowka and Hunter, 2003). A name for this new profession is *gold seller*, and a small industry has emerged out of it, for example in China (Dibbell, 2007). The question remains if the involved workers refer to themselves as players or workers, that is, if it is play or work they are performing. Using the definition by Statler et al. (2011) it would still be play as long as they have fun when playing, otherwise it would be work. While this is only one example, more and more areas emerge where play is mixed with concepts of work. The same is true for the other way around where concepts of play increasingly enter modern business life (Dovey and Kennedy, 2006, p. 19). Office employees are often discouraged by repetitive tasks, by lacking information of whether they are progressing and if they can expect a promotion, and by a detachedness of personal feelings and future company goals (Wang and Sun, 2011). Starbuck and Webster (1991) showed that by including playful elements in regular work life, aspects such as motivation, enjoyment, concentration, involvement and creativity of employees could be increased.

3. Games

With play being an activity free of any rules, encapsulated in a magic circle, a game acts as an antithesis by introducing structure and restrictions. A game usually has a start and an end and thus takes away some of the freedom of play (Fullerton, 2014). However, just seeing it as a restriction to play is not right, as both are different concepts (Deterding et al., 2011). On the contrary — a game enhances play with rules and order, gives it structure and motivates its players. Caillois and Barash (1961) situated the activity of play on a continuum between two poles: *paidia* and *ludus*. Pure play corresponds to *paidia* — free, expressive, improvisational and spontaneous play, as found in child's play. On the other side of the continuum is *ludus* which describes highly ordered, competitive, rule-based and goal-focused games. Thus, play and game denote two concepts which are related and opposed at the same time. This becomes even clearer in the English language, because both terms have different names, which is not true for other languages, like French or German (Salen and Zimmerman, 2004).

Games can take manifold forms — including card and board games, physical games and digital games. For this thesis, the last form is of particular interest. As a consequence, the following remarks about games are mainly tailored towards digital games. This does not mean that other forms of games are excluded. After a definition of the term game, this chapter will give an overview of digital games. Section 3.3 will then provide an overview of different aspects why games are fun and how they create enjoyment for different kinds of players. Parts of this chapter are derived from Campbell (2013).

3.1. Definition

With the huge variety of games, it is difficult to find only one globally valid definition for the term "game". Instead, multiple definitions have been presented. Common elements of them are *rules* (Juul, 2003; Salen and Zimmerman, 2004; Thai et al., 2009), an *uncertain but quantifiable outcome* (Caillois and Barash, 1961; Juul, 2003; Malaby, 2007; Prensky, 2007; Thai et al., 2009) *goals and objectives* (Adams, 2010; Charsky, 2010; Prensky, 2007; Thai et al., 2009), *interaction and feedback* (Prensky, 2007; Salen and Zimmerman, 2004), and a *degree of conflict or competition* (Caillois and Barash, 1961; Charsky, 2010; Koster, 2005; Prensky, 2007; Salen and Zimmerman, 2004). A compact definition of games comes from Adams (2010), stating that

> *"[a] game is a type of play activity, conducted in the context of a pretended reality, in which the participant(s) try to achieve at least one arbitrary, nontrivial goal by acting in accordance with rules"* (Adams, 2010).

What all these definitions have in common is that they base on the principle of play. Only when the aspects mentioned above are added will play become a game. If players just kick a ball around a field, it is play. But if they are told to kick the ball into the goal of the opposing team and that the team wins that has the highest score after 90 minutes, it becomes a soccer match. This simplified soccer game would have one rule (scoring a goal) and a goal (winning the game after 90 minutes), making it a full yet simple game.

3.1.1. Rules

Looking at the example of a soccer game above, the two necessary components are rules and goals. However, the goal can also be broken down to two rules, namely that the game ends after 90 minutes and that the team with the highest score is declared as the winner. Rules are thus the most fundamental element for play to become a game that implies the other concepts like goals, competition or interaction. Rules do not stand on their own, though. They depend on game objects and variables (Fullerton, 2014). A ball would be a game object that has its own variables such as position and velocity. Game time would be another variable that is not tied to any object other than the game itself. These two examples are objects/variables that are accessed by rules, but not altered. A variable like the score, however, is actively changed by a rule. As such, rules are also used to trigger game actions (Fullerton, 2014).

Simple games are built out of few rules. More complex games not only have more rules, but they employ different types of rules. Parlett (1999) presented a game rule analysis which comprises of eight categories (see Table 3.1). Salen and Zimmerman (2004) work with a categorization into three rule types, namely *operational*, *constitutive* and *implicit* rules. The rules from the soccer game presented above fall into the category "operational". Operational rules define the game logic that is visible to players and that they have to follow to play the game correctly. Thus, they can also be called *external* rules. In addition to that, a game can also have foundational/constitutive rules. These rules form the core mechanic of the game and can be called *internal* rules. For the soccer game the size of the play field or the shape of the ball are defined by such rules. In contrast to external rules, however, non-digital and digital games differ in the use of internal rules. With non-digital games, players normally have to know both external and internal rules to play the game. For example, with a board game, players have to know when to roll which type of dice to generate an action in the game. With digital games, however, such internal actions can be performed transparently for players. In a digital game a player could move to the next field on a game board, and an internal rule could then determine the action by using a random number. The player would not have to know what the random number looks like exactly, because only the external rule (i.e., the action in the game) is important for the game to proceed. Another aspect of internal rules is that they can be changed without touching external rules. If in the soccer game the ball was exchanged for a larger one, players could still follow the same external rules of scoring goals and winning the match.

In addition to external and internal game rules, there is a third category that both Parlett (1999) and Salen and Zimmerman (2004) mention. Other than the previous two, it does not refer to the game itself but to the environment around it. These behavioral/implicit rules

Table 3.1.: Game rule analysis by Parlett (1999), in Schell (2008).

Rule	Description
Operational Rules	Rules a player has to follow to play a game.
Foundational Rules	Internal rules of the game mechanic.
Behavioral Rules	Implicit rules how to behave during gameplay.
Written Rules	The game manual.
Laws	Official and detailed rules for tournaments or serious occasions.
Official Rules	A mixture of written rules and laws.
Advisory Rules	Tips and hints for a successful gameplay.
House Rules	Adapted rules for a certain occasion or a set of players.

come into play where external rules end. They describe general guidelines how the game should be played and are especially important when there are multiple players in a game. An often cited example is the time between rounds in a round-based game which should not exceed a certain threshold, even though there is no explicit rule for it. In general, players should be polite to each other and use common sense when playing with each other to follow the behavioral/implicit rules. The analysis by Parlett (1999) names even more rules that refer to special occasions or different modes of gameplay, like tournaments or adapted rules when playing with a certain set of players (see Table 3.1). Apart from the categorization of rules, Juul (2005) mentions another aspects of how rules and games are connected. In his book *Half-Real*, he argues that rules are strongly connected to the fictional elements of a game, because

> *"[the] player [...] experiences the game as a two-way process where the fiction of the game cues him or her into understanding the rules of the game and, again, the rules can cue the player to imagine the fictional world of the game."* (Juul, 2005)

As such, rules not only define the core logic of a game, but they also help players to understand the game as a whole and make the game more believable. This should also be considered in serious games, so that rules that are connected to the serious aspects of the game are included into the theme of the game in a meaningful way.

3.1.2. Game Categories

Rules define how a game is played and what actions players can take. By specifying a set of rules, any form of game can be created. Many games share a set of common rules and can be still assigned to different categories. Caillois and Barash (1961) provided a categorization of games that works with four fundamental elements:

Agôn Agôn bases on the element of competition that originates from players competing against each other. Agôn games require absolute attention, discipline, perseverance, and players usually train extensively, propelled by the desire to win. An example for such games are sports matches or board games such as chess.

Alea Chance is the main element of alea games. The outcome of such games is arbitrary, and players cannot do much to influence it, other than waiting passively. A coin toss is a trivial example for alea games.

Mimicry Mimicry is a term that originally describes how insects imitate other insects as a deterrent. Caillois and Barash uses it to describe the concept of role-playing (i.e., slipping into a different role). Examples for this element are children's role plays or theater plays. In conjunction with digital games, the genre of role-playing games (RPGs) is an obvious representative of mimicry games.

Ilinx The concept of ilinx refers to the feeling of vertigo that creates an altered perception, such as roller coaster rides or children spinning on a swing. Ilinx games *"inflict a kind of voluptuous panic upon an otherwise lucid mind"* (Caillois and Barash, 1961, p. 19).

These categories should not be seen as mutually exclusive, because many games employ more than one of them. For example, ski jumping is a mixture of agôn and ilinx, because it includes competition and vertigo. According to Brezinka et al. (2007), this is especially true for digital games. Then again, the category of ilinx has not been considered much by digital games so far, because they are usually not able to physically move a player (Schrammel and Mitgutsch, 2009). However, this is changing because of the recent usage of virtual reality (VR) techniques such as the Oculus *Rift*. Adamowsky (2005) furthermore argues that there is a missing fifth category, namely *the experiment*, that is not covered by the existing ones. It describes the concept of planning and modeling tasks that can be found — among others — in real-time strategy (RTS) games.

Taking into account the vast amount of available games, Caillois and Barash's scheme can only provide a coarse categorization. The presented four categories — or five, including Adamowsky's extension — are not enough to fully describe a game. For example, soccer and chess both fall into the category of agôn, but they deploy very different game mechanics and rules. One is played by two teams, the other by just two players. Soccer is played on a field by kicking a ball whereas chess takes place on a board by moving and defeating pieces. Thus, to fully describe a game, all different rules and mechanics have to be taken into account.

3.2. Digital Games

Within the discipline of games, digital games are a relatively new area. However, they have gained great popularity during the last few years. Just like their non-digital counterparts, they are built to entertain and thus act as an alternative to books, theater plays or movies.

While those are mostly passive media, games allow players to interact with the game and other players, making them even more interesting and fun to play.

When speaking of digital games in this thesis, the term comprises all types of games that exist as digital media. For the sake of simplicity the terms "video game", "computer game", or simply "game" will be used in this thesis interchangeably to refer to digital games played on a computer, a console, a handheld device, or a smartphone. Fun is the driving factor for all these games. However, the factors how games create fun are manifold. An overview of these factors will be given in this section. To further build a solid foundation for considering digital games, a brief introduction on the gaming industry and its history will be given as well.

All digital games have in common that they are played on some kind of digital device. This can be a dedicated console which uses a TV screen to display the game and normally uses a specialized controller as input that comprises a set of knobs and buttons (Ellis et al., 2006). Recent examples for such devices are the Sony *Playstation*, the Microsoft *Xbox* and the Nintendo *Wii*. Alternatively, games can be played on a regular computer. These games are usually controlled with keyboard and mouse. In addition to stationary devices, digital games are also played on mobile devices. Those can again be dedicated handheld consoles with a built-in screen, such as Sony's *PSP* and Nintendo's *3DS* or the older *Game Boy*, or general-purpose devices in the form of modern smartphones. The main difference between all devices are their input and output capabilities. For example, a game for smartphones probably has to be adapted due to the smaller screen size in comparison to computer monitors, but at the same time the game can use the touchscreen as an intuitive input controller. The main game mechanics, however, do not differ across the different platforms. As a consequence, digital games refer to games on any platform in this thesis, unless specified differently.

Industry and Game Demographics

Compared to the basic list of game types presented in Section 3.1.2, digital games are very diverse and span from simple single-player puzzle games to fast-paced massive online action games. Additionally, there are far too many single games for players to remember all of them. While there are many different games, however, many games share common characteristics. A categorization into *game genres* thus helps to memorize and understand the basic mechanics of games. Prensky (2007, p. 130f) lists action, adventure, fighting, puzzle, RPG, simulation, sports and strategy as genres. Adams (2010) presents a another comprehensive overview of game genres with nine categories: action, strategy, RPGs, sports, vehicle simulations, construction and management simulations, adventure, artificial life and puzzle games, and online gaming. According to sales in the U.S. from 2014, action games are the most popular genre with a share of 28.2 percent, followed by the similar genre of shooter games (21.7 percent) (Entertainment Software Association, 2015). This is in line with the global sales charts from 2014 where — counting numbers from all platforms — *Call of Duty: Advanced Warfare* was the top-selling game[1]. Still, other game

[1] `http://www.vgchartz.com/yearly/2014/Global/`, accessed 08.10.2015.

genres such as racing, puzzles, sports, and adventures enjoy great popularity, too. Lenhart et al. (2008) found that 80 percent of U.S. teenagers play at least five different game genres. In 2008, for example, the most popular titles were *Guitar Hero*, *Halo*, *Madden NFL*, the puzzle game *Solitaire*, and *Dance Dance Revolution*.

The first video games were created in the 1960s and were hardly more than by-products of research in software engineering departments of universities (Trepte and Reinecke, 2010). Commercial production of digital games did not start before the 1970s, when the first game consoles were available (Williams, 2006). Following the rapid development of digital technology, games became more and more popular until the first games were accepted as cultural artifacts (Fritz et al., 2011). They evolved from simplistic pixel animations to the complex three-dimensional multimedia applications they are today (Trepte and Reinecke, 2010). As a result of its success, the digital game industry has overtaken the movie industry in revenue with growth rates of 10.6 percent per year from 2005 to 2009 in the U.S. market (Kirriemuir, 2002; Siwek, 2014). In 2014, U.S. consumers spent $22.41 billion on digital games, game platforms and accessories (Entertainment Software Association, 2015). These numbers go along with an increasing playtime of an also increasing amount of players. In 1999, children on average only spent 26 minutes daily playing video games (Rideout et al., 2010). Von Ahn and Dabbish (2008) stated that the average player nowadays will have accumulated over 10,000 hours of play time by the age of 21 — comparable to five years of work in a full-time job.

The Entertainment Software Association (ESA) that has many video game publishers as members releases annual reports about the video game demographics in the USA. In 2014, four out of five households owned a device that was used to play video games (ESA, 2015). The age of the average player in 2014 was 35 (30 in 2011), with 26 percent of the players being younger that 18 years (32 percent in 2011) (ESA, 2012; ESA, 2015). The increasing age of players is an indication that the first generations of players who started when they were children did not stop playing until now. At the same time, children and adolescents tend to play more each year. Multiple studies about this development have been conducted. Rideout et al. (2010) reported that 60 percent of U.S. adolescents play digital games each day, compared to 52 percent in 2004 and 38 percent in 1999. According to Gentile (2009), the part of the Americans aged 8–18 that played a video game at least once was 88 percent, and the number of frequent players, playing at least three or four times a week, was 52 percent in this age group. A survey by Lenhart et al. (2008) resulted in even higher numbers in the age group of 12–17 years where 97 percent stated that they already played some kind of digital game. Furthermore, the prejudice that the vast majority of players is male does not hold true anymore, as 44 percent of players were female in 2014 (ESA, 2015). Social aspects play an important role, too: 62 percent of all players indicated they played with others, either in-person or online (ESA, 2012). When it comes to time spent with leisure activities, games directly compete with other media. In 2014, U.S. gamers indicated that since they played video games, they watched 39 percent less TV, were 40 percent less likely to go to the cinema or watched 47 percent less movies at home (ESA, 2015). All these statistics show that digital games have become a mass medium that is established as mainstream and is neither male-dominated nor an activity

confined to adolescence. As a consequence, serious games also have the potential to reach a broad audience by delivering serious matter in a playful way.

3.3. Motivation and Fun in Games

The term game usually refers to games that a solely made to entertain their players. This is in contrast to serious games that have an additional purpose, but still are designed to entertain, as further explained in Chapter 4. From the perspective of game publishers, the entertainment potential of games may only be a side product, and the actual reason to make games is to make profits. However, for the course of this thesis games will be primarily seen from the player-centric view that they are only made to entertain. As shown in the last section, digital games indeed have become a mass market and attract all kinds of players — young and old, male and female. What exactly is the reason for games being so successful in entertaining their players, though? To clarify this, the current section will present an overview of how games create fun and what entertainment in context of games means. These are important factors for the creation of serious games, because they build up on the motivational factors of games to deliver their serious content to players.

3.3.1. Flow

A fundamental concept that explains how humans get motivated for any task is the *Flow State*. As such, it is also crucial for games. Flow describes a state of complete concentration and immersion into an activity. Csikszentmihalyi (1991) formulated the concept to give an answer to the question why people immerse into activities without any external triggers or rewards. He discovered that if an activity possesses certain attributes, it becomes

> *"so gratifying that people are willing to do it for its own sake, with little concern for what they will get out of it, even when it is difficult or dangerous"* (Csikszentmihalyi, 1991).

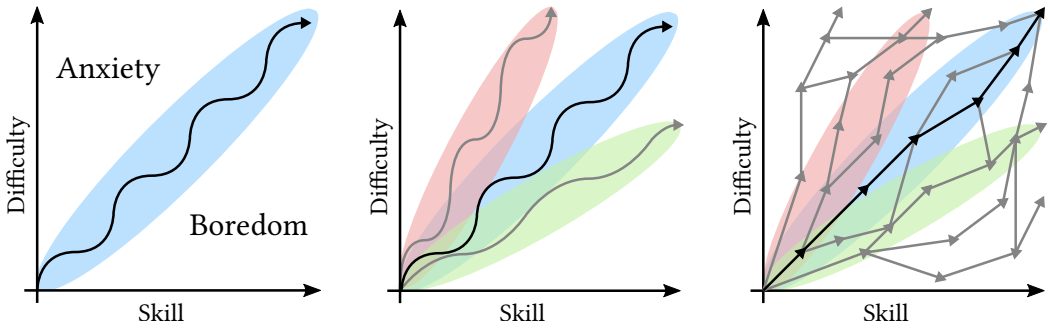
When entering the "flow zone", people are intrinsically motivated and want to continue with the task. They are fully dedicated to it, tend to fade out the world around them and lose track of time. This results in an increased performance while the experience itself is perceived as reward (Csikszentmihalyi, 1991).

Several criteria should be met to get into the flow zone. According to Chen (2007), the majority of the following characteristics have to apply to enter it:

- The task can be completed.
- The user is able to concentrate on the task.
- The task has clear goals.
- The task provides immediate feedback.
- The user is able to exercise a sense of control over actions.

- The user shows a deep but effortless involvement that removes awareness of the frustrations of everyday life.
- The user's concern for the self disappears, but the sense of the self emerges stronger afterwards.
- The sense of the duration of time is altered.

The flow state is not limited to the domain of games. On the contrary, it applies to any activity that lets participants immerse. Those activities do not even have to be playful, such as regular work, cooking or writing. Supervisors — including instructors, trainers or game designers — can help their users to get into the flow state by designing tasks accordingly. Thereby, they face a non-trivial balancing act between boredom and anxiety (see Fig. 3.1a). Users that find a certain task to be too simple — because their skill is too high or the task too easy — will soon get bored and thus cannot enter the flow state. Then again, users that face a task that is too difficult for their skill level will get overwhelmed and frustrated. They will not enter the flow state either. The perceived skill level is susceptible to subtle aspects. For example, a first person shooter (FPS) game might be perceived as too difficult by novice gamers just because they are not used to controlling games with both mouse and keyboard. Hardcore gamers, on the other hand, might find the overall difficulty of the game too easy. As a result, both gamer groups would stop playing the game, although for different reasons (see Fig. 3.1b) (Chen, 2007). Even if there are players whose skills match the requirements of the game, it still can happen that they lose interest in the game, because their skills improve at a different pace than the difficulty level of the game. Additionally, if both challenge level and player skill are are low, players will experience apathy (Admiraal et al., 2011; Sweetser and Wyeth, 2005).



(a) Flow zone (b) Flow and player skills (c) Flow by adaption

Figure 3.1.: Designing flow in video games. Source of original image: (Chen, 2007)

Despite the potential difficulties in integrating the flow concept into games, game designers have put much effort into achieving this goal. After all, it is a prerequisite for players to fully enjoy a game and to be entertained by it. Common techniques used in this regard are to clearly communicate goals to players, to offer tutorials to players, to give immediate feedback to all actions, and to let players be in control of the important

aspects of the game. However, games always have to cope with differing player skills, as shown in Fig. 3.1b. To mitigate this problem, many games offer selectable difficulty levels. This approach is far from optimal, though, because players have to decide themselves which difficulty level suites them best. A better alternative is to offer players different paths through a game by providing a set of levels with varying difficulty levels. With this fine-grained approach players can decide whether they want a relaxed play session or a new challenge with each new level (see Fig. 3.1c) (Chen, 2007). A yet not fully solved problem, however, is the automatic adaption of a game to the player's skill levels, which would provide an optimal play experience (Wendel, 2015).

3.3.2. Motivational Factors

Enhancing the fun of a game leads to a higher motivation and therefore the user is more engaged in playing. Malone (1980) even uses the terms "fun", "interesting" and "intrinsically motivating" synonymously. Historically, he only established three categories of game characteristics in 1981: challenge, fantasy and curiosity. Many models have been presented since then that examine game elements on a more detailed level regarding the fun they create:

- Caillois and Barash (1961) created a list of four elements: agôn, alea, mimicry, and ilinx (see Section 3.1.2).
- Apter (1991) created the following list: exposure to arousing stimulation, fiction and narrative, challenge, exploration, negativism, cognitive synergy, and facing danger.
- Hunicke et al. (2004) list eight elements of how games create fun: sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission.
- Prensky (2007) lists twelve elements: fun, play, rules, goals, interactivity, outcome and feedback, adaptivity, win states, conflict/competition/challenge/opposition, problem solving, interaction, and representation and story.
- Adams (2010) lists the following elements: gameplay, aesthetics, harmony, storytelling, risks and rewards, novelty, learning, creative and expressive play, immersion, and socializing.
- Charsky (2010) created a categorization consisting of the five elements competition and goals, rules, choice, challenges, and fantasy.
- Fullerton (2014) defines the *"dramatic elements"* of a game as follows: play, challenge, premise, character, and story.
- Sweetser and Wyeth (2005) proposed a model for elements that create enjoyment in games called *GameFlow*. It uses the flow theory by Csikszentmihalyi (1991) and distinguishes between eight elements: concentration, challenge, skills, control, clear goals, feedback, immersion and social interaction.

From this multitude of characteristics, a set of common denominators can be derived which will be presented in the following.

Play

Play on its own — without any game elements — is a big motivational factor. The fact that this activity is performed without any external triggers shows that play engages and is fun. Since games and play are closely related concepts, play can or should also be a part of a game. Csikszentmihalyi (1991) therefore used the term *autotelic*, a combination of auto (self) and telos (goal). Transferred to the stricter form of games, players should still be allowed to freely explore the game world and to experiment without fearing consequences. It does not matter if these actions arise out of a specific interest or pure curiosity as long as players are able to experience pure play within a game. One way to implement such a feature is to provide a sandbox mode that is not connected to the story or clear goals. *Minecraft* is a popular example where the sandbox mode even is the main game mode. Players spent countless hours of play to build complex structures — including spaceships and working computers — and to explore the world. This shows the big motivational potential that arises out of pure play.

Challenges and Goals

To solve a challenge and to work towards a goal are strong motivational factors. As described in Section 3.3.1, the difficulty level of challenges have to match the player's skills to be effective as a motivation. However, this general rule does not say anything about the form of the challenge. Several other aspects have to be considered as well. Adams (2010) states that there normally is not just one challenge/goal in a game, but they are nested within each other. The biggest challenge often is the final completion of a game. Before this can be achieved, players have to solve a set of missions or levels which, again, can have sub-missions. The smallest unit of challenges are so-called atomic challenges. These can be to defeat a single enemy, to answer a question correctly or to solve some kind of puzzle. The primary focus of players lies on mastering the immediate next atomic challenge, because it is the most specific task at any point in time in the game. To keep up the long-term motivation, players should always be aware of the mission goals and the overall goal of the game, too. Otherwise players might lose the big picture of the game and lose interest in it. That does not mean that games should be completely transparent to players, though. For example, in a detective game goals might change due to new traces or spotted evidence, leading to different outcomes (Adams, 2010, p. 255). Ideally there should not only be one way how to solve a challenge but multiple ones. Goals should be reachable using different paths through the game, and they should leave space for experimenting or failure (Lieberman, 2006).

Challenges in games come in two different forms: *explicit* and *implicit* (Adams, 2010, p. 255). Explicit challenges have a clear goal, and the way how to achieve it is given. For example, a tutorial only consists of small explicit challenges so that players get introduced to the more complex game that is following. In contrast, when facing an implicit challenge, players also have a goal but they have to find out how to reach it on their own. Therefore they have to think about possible solutions and possibly combine previously acquired knowledge. Both forms of challenges should be in balance in a well designed game. Too

many explicit challenges will restrict the players' freedom, but at the same time too many implicit challenges will result in players getting lost, because they do not have a clear goal to pursue.

Adams (2010, p. 259) states that the difficulty of a challenge depends on two factors, namely *intrinsic skill* and *stress*. The former is the skill needed to master a challenge without time pressure, while the latter adds time pressure to a task. To overcome a difficult challenge can increase self-esteem, both in a game or in the real world. However, the amount of own work in solving the task seems to be secondary, because this fact also applies to alea games, which are mostly or totally based on chance (see Section 3.1.2). A negative side is that players which often fail a challenge will also get a decreased self-esteem and thus lose motivation in playing a game. Just like with explicit an implicit challenges, the right balance is important to keep players motivated. A way to do this is to offer various difficulty levels for players but also by providing a clear feedback on the player's performance (Malone, 1980).

Risks and Rewards

The element of uncertainty is an important factor when it comes to player motivation. Without any uncertainty, a game would become totally deterministic. While there still could be challenges in the game that require some level of skill, a player would always know what the exact consequences of his or her actions are. This can be changed by introducing the element of risk that contributes to the perceived motivation and enjoyment (Wang and Sun, 2011). The basic form of risk would be gambling or alea games. However, every competitive game includes some kind of risks for players. For example, if in real-time strategy games there is only one predefined strategy that guarantees players to win the game, the game itself does not hold any entertainment value, because the element of risk is missing. Then again, if the game was totally based on chance, players could not develop a strategy or would fail too often which again would decrease the entertainment value. Including risks into a game is thus a vital measure to make a game engaging. Only including risk alone, however, is not enough. For each risk there must be an award that corresponds to the level of risk and the invested effort. In that way, players can be lured into taking risks (Adams, 2010, p. 23).

Rewards will not only engage players once they receive them, but the mere anticipation of the reward will motivate players as well (Wang and Sun, 2011). While a risk always includes the option of failing, games should not additionally punish players, but give them the opportunity to try again (Prensky, 2007). Rewards a player can achieve after fulfilling a risky task can have different forms. Salen and Zimmerman (2004) list four kinds of rewards:

- *Rewards of glory* present the players with objects that are not relevant for the progress of the game, but just act as a trophy. Score systems are an abstract form of this reward type which are effective especially for online games (Wang and Sun, 2011).

- *Rewards of sustenance* enable players to play a game longer by replenishing resources such as health for the in-game avatar. Collectible resources also act as rewards of this category (Wang and Sun, 2011).
- Upon receiving *rewards of access*, players are granted entry to previously locked areas in the game, such as locked rooms or bonus levels. Malone (1980) argues that this category is especially important, because it includes the element of hiding information from the player, and incomplete information in a game is a great contributor to curiosity and motivation.
- *Rewards of facility* are upgrades to to players' abilities in the game and thus directly influence the game. For example, in an avatar-based game this could be new skills or just experience points (Salen and Zimmerman, 2004, p. 346).

Wang and Sun (2011) extended the four categories by another one that includes purely visual rewards such as visually attractive animations and pictures players can earn for solving risky challenges.

Storytelling

Malone (1980) stated that just adding goals and challenges to a game is not enough. Instead, players should be able to identify with the game, its characters and the outcome. This observation was affirmed in a study where children preferred a game in which a child that was experiencing some kind of adventure was the main character (Malone, 1980). In general, the element of storytelling is another strong motivational factor. When drawn into a story, people want to know how it continues. This is true for other media as well, such as books or movies, but games are especially suited for telling stories because they allow players to influence the story and its outcomes. Therefore, many games provide alternative paths through the game so players can decide which path to follow, for example a good or an evil one. A common template for creating an appealing story is the *Hero's Journey* (Campbell, 1968). It includes several stages where players experience ups and downs and grow more powerful until they face the final battle.

Learning and Curiosity

Even though most games are made for pure entertainment, the aspect of learning is still an important factor when it comes to player motivation. It does not have to be as explicit as in dedicated learning tools. On the contrary — any game that requires players to learn a new approach or to develop a winning strategy will encourage and motivate.

According to Koster (2005), the reason for this can be found in the way the human brain works. As soon as humans experience fun or pleasure, endorphins will be released. Interestingly, this does not only apply to obvious examples such as eating chocolate, but it also applies if humans learn something new:

> *"Fun from games arises out of mastery. It arises out of comprehension. It is the act of solving puzzles that makes games fun. In other words, with games, learning is the drug."* (Koster, 2005)

As the human brain is always seeking for new things to acquire, boredom will arise if there is nothing new to discover. However, if the novelty is overwhelming, the brain will not be able to process the information which results in frustration. Only a right balance between new concepts and already acquired knowledge will lead to an optimal motivation (Koster, 2005). This consideration is an important factor for all games, but it is especially interesting for the creation of learning games that are specifically made for teaching and delivering new knowledge.

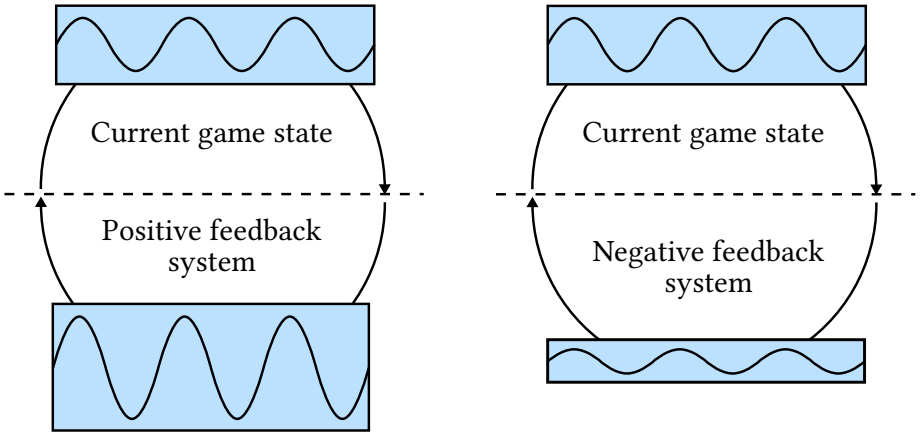
A closely related concept to learning is the aspect of curiosity. To address the curiosity of players, games must offer the element of surprise and complex game contents that players have to explore and to comprehend. Again, the level of complexity should not be too high for players to understand. As a rough guide, a game should provide expectable outcomes most of the time, and only sometimes there should be actions with unexpected and surprising results (Kirriemuir and McFarlane, 2004; Malone, 1980). Two forms of curiosity can be integrated into games (Malone, 1980). *Sensory curiosity* applies to audio-visual stimuli that catch the player's interest. It could be a light shining in the distance or a distinct sound that attracts the player's attention to find out what lies behind it. The other form is *cognitive curiosity* which can be created by more abstract stimuli, for example a story that only reveals parts and leaves other parts to be discovered by the player.

Feedback

Users expect feedback about their actions (Adams, 2010, p. 200). In digital games, feedback is even more important for player satisfaction and motivation. Juul (2010, p. 50) calls positive feedback on every little successful action the "juiciness" in a game. It lets players feel clever and competent and gives them the feeling of control. A practical view of feedback is that it gives players the possibility of oversee the consequences of their actions and to assess if they were good or bad for the course of the game. This is true both for single-player and multiplayer games where players can see how they perform in comparison to other players (Prensky, 2007, p. 121). Feedback can be subtle like a sound and vibration of the controller, or it can be noticeable, up to displaying the "game over" screen when the game is lost. In any case, it should always be appropriate and constructive (Malone, 1980). According to Lieberman (2006), feedback in a game — if implemented correctly — can be as effective as a conversation between an instructor and a student which is an important consideration for serious games. Charsky and Mims (2008) suggest to include feedback into serious games in the form of *"debriefing sessions, reflective activities and evaluation"* with both players and instructors.

Apart from user feedback, the term also relates to internal game adaption mechanisms that also influence the player's perception of the game. Feedback systems in games work by adapting parameters of the game logic to make the game harder or easier for players, both in single-player and multiplayer games (see Fig. 3.2). In a *negative feedback loop*, the adaption intervenes as soon as parameters have fallen below a certain threshold, that is, when a player or a non-player character (NPC) is in danger of losing (Adams, 2010, p. 350) (see Fig. 3.2b). Salen and Zimmerman (2004) name the example of racing games as representatives for such mechanisms: If the player falls behind, the NPC-controlled cars

will decelerate so that the player can catch up again. On the other hand, if the player is in lead, other cars will become faster so that the player still gets challenged. As a result of negative feedback loops, games will get more balanced and thus will take longer to finish. The opposite is true for a *positive feedback loop* (see Fig. 3.2a). Here the winning team/-player will get reinforced, resulting in an even clearer victory and shorter game. Since this disadvantages weaker players, most games refrain from using pure positive feedback loops. However, if combined with an increasing difficulty level, they can help players to stay in the flow zone. For example, characters in RPGs will get stronger with each accomplished mission, but at the same time they will face stronger enemies. Especially negative feedback systems, however, are important in the context of serious games, because they allow games to adapt to the player's capabilities.



(a) Positive feedback system (b) Negative feedback system

Figure 3.2.: Basic functioning of feedback systems that can also be used in games.

Other Factors

In addition to the list presented above, there are more factors that contribute to the perceived fun in games. *Controls and usability* are elements that are not related to the actual game mechanics. Since both provide the interface between players and game, however, they have to be implemented well for the other factors to be effective. Related to the genre of online games, Wang et al. (2009) tested 30 categories which contribute to player enjoyment. They found that controls, usability and mechanics were listed among the top-rated categories, showing the relevance of these criteria. They manifest in factors like how intuitive the controls are or how many bugs are present in the game. Adams (2010, p. 252) emphasizes the relevance by pointing out that games should always follow a player-centric game play.

Social factors are another characteristic that contributes to create a fun experience in games. By socializing, players build a team spirit, for example if they successfully fight a

powerful enemy in a MMORPG together with other players because they to do things that cannot be done alone. The interaction does not need to be performed with other players, though. NPCs can also be used when players can identify with them.

Finally, *aesthetics* of a game alone can be a factor that engages players in playing the game. This includes the artistic style of the game and especially how it presents itself to the players. An impressive graphical presentation alone can attract players to play a game. For example, the — at the time of release — new and modern 3D graphics were major selling points of the *Unreal* and *Crysis* game series.

3.3.3. Player Types

Even though there is a multitude of factors that contribute to the fun players experience in games (see Section 3.3.2), not all of them apply to all players in the same way. The simple reason for this is that no two players are the same. On the contrary, players differ just like human personalities and behaviors differ (Hartmann and Klimmt, 2006b). However, several common characteristics have been identified in the literature which help to categorize different types of players. A ground work has been laid by Bartle (1996) who presented a player categorization for multi-user dungeons (MUDs), an early version of today's online games such as MMORPGs. He uses a two-dimensional space which maps players to four different types (see Fig. 3.3). Since this model has been used frequently by other researchers and game designers, it is presented in detail before looking at finer grained models.

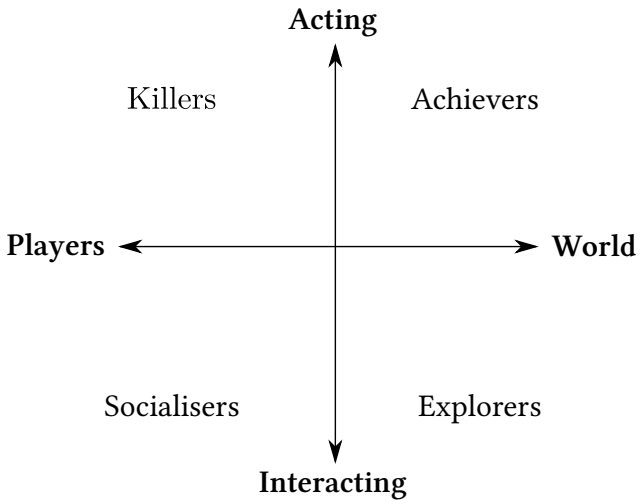


Figure 3.3.: Player types according to Bartle (1996).

Achievers

The driving force for achievers is to proceed in the game, that is, to gather points, level up and to reach all achievable goals in a game. They see other mechanics in games mainly

as a mere expedient for solving a task that brings them nearer to their goal. Achievers tend to take playing seriously, and playing a game can be compared to participating in a sports competition in the real world. Due to the serious character of the goals, this group of players is most likely to "work" while playing, although they play in their leisure time (Fritz et al., 2011, p. 277). Games that attract achievers have to include clear goals and instructions how to achieve them. As such, games that consist of many levels or missions and that include a scoring system are most likely to be played by achievers (Reeves and Read, 2009, p. 27).

Explorers

On the axis of acting to interacting, explorers constitute the opposite of achievers. Explorers are not much interested in completing a game but they are interested in finding out every detail of how the game works. They curiously investigate the game and its mechanics. They even perform actions that do not necessarily have to be connected to any mission or goal within the game. Their goal is to find out the "wiring of the game", that is, the internal game rules that may be hidden from players in the first place. With games that have a game world where players can move around, explorers try to reveal every part of the world and find all hidden places. However, they also try to find the limits of the game rules, possibly finding bugs in the game.

Killers

Just like achievers, killers seek competition in games. In contrast to the former group, however, they look for competition with other players instead of the game world (i.e., missions and NPCs). The main goal of killers is to dominate other players up to the point of harassing and humiliating them. As such, killers can primarily be found in multiplayer games that allow player confrontation. They find satisfaction in defeating other players in regular fights, but they can also harass other players in whatever ways the game allows. Some killers do not seek for confrontation but follow a benefactor role where they use their skills to assist other — mainly weaker — players to get rewards in form of admiration and respect.

Socialisers

Socialisers form a special player type, because their main interest does not lie in the game. Instead, their goal is to meet other players, to spend time with them and to foster relationships. While they also enjoy playing a game, completing the game is not important. Socialisers see a game as a platform to communicate, and thus they can exclusively be found in multiplayer games. Their progress in a game can be traced back to the desire of staying close to friends who otherwise would be out of reach, for example, because the skills and character levels are too different. Fritz et al. (2011, p. 277) remark that this player type is often found with players who do not have many contacts in the real world. Mostly playing in a group, socialisers will be crucial to the group's well-being by caring about the coherence of the group and its players. Games that offer cooperative game mechanics

and features such as parties and guilds are the main target group for socialisers. They do not only seek for gratification in the games themselves, but they can also be encouraged by external activities such as posting in online forums, as pointed out by Wang and Sun (2011) in their description of game reward systems.

3.3.4. Extended Player Types

Since Bartle (1996) presented his player type categorization, digital games have been rapidly developed further, and whole new genres of games arose. This evolution has also been included into recent considerations about available player types in modern digital games. A categorization that directly bases on Bartle's work was done by Yee (2006b). The presented model was developed by looking at MMORPGs, a derivative of MUDs. It basically uses the four player types as well, but Yee separates them into finer grained categories (see Table 3.2). Fullerton (2014, p. 92) presented another categorization of player types with ten types in total with no specialization to a certain game genre. She also incorporated Bartle's player types and enhanced them with aspects that can be found in games other than online games. Both lists omit the mainly destructive player type "killer". Yee condensed killers and achievers into the same category of achievement, while Fullerton transformed it into "the competitor". The newly introduced element of immersion is split into four categories by Yee, including the base type "explorer". Then again, Fullerton considers additional types such as "the artist" or "the craftsman" which are not explicitly covered by the other lists. All lists have in common that the categories are not necessarily mutually exclusive, that is, players will most likely show traits of multiple player types.

Apart from psychographic factors that the models by Bartle and others base on, demographic factors influence the preference toward types of games and game mechanics as well. Differences between genders have often been discussed when in comes to games, showing that both genders strive for games with different aspects (Admiraal et al., 2011; Hartmann and Klimmt, 2006a; Koster, 2005; Mitchell and Savill-Smith, 2004). For example, men prefer to have competition and spatial puzzles in games, whereas women prefer nurturing and verbal puzzles (Schell, 2008, p. 103ff). For a long time, male players outnumbered female players. Reasons for this might have been that digital games were situated in the technical and male-dominated domain of computer technology, and perhaps also the fact that most of the game designers were male. As a result, games have been designed for males as the primary target group (Ivory, 2006). However, this has changed. Recent numbers published by the ESA show that 44 percent of the players in the USA were female in 2014 (ESA, 2015). This trend continues as more and more game designers are nowadays women (Gaudiosi, 2015). The age of players is another important demographic factor. Children, adolescents, adults and the elderly do not only differ in the time they spent playing games, but they also play different kinds of games. All the different factors make it close to impossible to create games that are enjoyable for all players which is one of the reasons why there exist so many games. With the right combination, however, games are able to motivate players and to immerse them into the game world so that they have fun and forget the world around them.

Table 3.2.: Extended player motivations according to Yee (2006b).

Category	Examples
Achievement	
Advancement	progress, power, accumulation, status
Mechanics	numbers, optimization, templating, analysis
Competition	challenging others, provocation, domination
Social	
Socializing	casual chat, helping others, making friends
Relationship	personal, self-disclosure, find and give support
Teamwork	collaboration, groups, group achievements
Immersion	
Discovery	exploration, lore, finding hidden things
Role Playing	story line, character history, role, fantasy
Customization	appearances, accessories, style, color schemes
Escapism	relax, escape from real life, avoid real life problems

3.4. Summary

Games are closely related to the concept of play. At first sight games seem to be contradictory because they restrict play in that they shape play into a stricter form and at the same time enhance play by introducing new aspects to it. The most basic feature how play and games differ are rules. They give play a structure and define what actions players can perform and what the players have to do to win a game. By combining rules and goals, all different kind of games can be created which can be coarsely separated into four categories that define what elements are contained in them (Caillois and Barash, 1961).

Digital games, including games on PCs, consoles and mobile devices, emerged in the 1970s as a new form of entertainment and have become a mass market attracting millions of players. The simple reason for their success is that they are fun: they engage players with interactive stories, competitive fights with other players or visually pleasing graphics.

A fundamental concept that explains how humans get motivated and engaged in a task is the flow state (Csikszentmihalyi, 1991). Applied to games, players should always be in balance between their skills and the difficulty of the game. Various features add up to the perceived engagement players experience, including challenges, risks, story and learning. Due to the diverse human nature, not all games appeal to all players in the same way. Players can be categorized into different player types that classify what they prefer to do in a game. For example, some players like to compete with other players while others like to explore the game world. With their huge motivational potential, digital games are now recognized as a form of art and as an integral part of society.

4. Serious Games

At first appearance the term "serious game" might seem like a paradoxon. With play being a free activity detached from any restrictions and games representing a form of pure entertainment, how should there be anything serious about them? For a long time, exactly this has been common belief. Only recently a paradigm shift has started that allows play and games to be used in serious contexts. While it is true that both are fun, the analysis in Part I also showed evidence that both concepts inherently include "serious" components. After all, play and games have been used by children from the beginning of human history to playfully learn and to simulate potentially dangerous real-life situations. So, is the term serious games just a pleonasm, because all games are serious by definition? Or is it rather an oxymoron, as serious and game are contradicting concepts, especially when considering the historical meaning (Djaouti et al., 2011)? This chapter will give an overview of the common definitions and history of serious games. Furthermore, the application areas of serious game will be presented.

4.1. Definition and Background

Compared to games in general, serious games are still young and just came up at the time when digital games where becoming popular in the 1970s. The term was introduced by Abt (1970) with his book *Serious Games*. With an absence of games specifically made for serious purposes, the examination of serious games started with generic games that could be used in educational settings (Breuer and Bente, 2010; Lampert et al., 2009). This movement stayed a small niche market until 2002 when *America's Army* was released which is considered to be the first largely successful serious game. Together with the foundation of the serious games initiative by Ben Sawyer and David Rejeski, the serious game movement gained more and more resonance (Breuer and Bente, 2010; Popescu et al., 2012). Until now, the field is growing steadily (Susi et al., 2007). The serious games communities are still largely fragmented which on the one hand allows for new and innovative developments but on the other hand makes it difficult to even find homogeneous definitions of the term itself.

4.1.1. Definition

Abt (1970) first used the term "serious game" for any game that is used in an educational setting. This core statement can also be found in more recent definitions. For example, Michael and Chen (2006) define a serious game as *"a game in which education [...] is the primary goal, rather than entertainment"*. The definition of Corti (2006) is more general, stating that serious games are *"the use of computer game and simulation approaches and/or*

technologies for primarily non-entertainment purposes". Other definitions do not work with this clear distinction that entertainment must not be the primary goal in serious games. Zyda (2005) states that serious games should be seen as

> *"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, p. 26)

Prensky's definition follows a similar idea, namely that *"games should be fun first and then should encourage learning"* (Prensky, 2007). These definitions are more in line with the ones from regular games (see Section 3.1), saying that games should be fun in the first place. Koster's argumentation is in line with the observations about play that the concepts of fun and learning are inherently connected. As a consequence, fun in games should not be an addition to the learning activity, but fun should be a product of the learning activity itself (Admiraal et al., 2011; Koster, 2005; Michael and Chen, 2006).

Apart from the way how serious games should be played and enjoyed, there are also discordant opinions how serious games should be designed. The more conservative view is that only games that were explicitly designed with a serious background in mind should be called serious games. This opinion is shared by Ritterfeld et al. (2009), defining serious games as *"any form of interactive computer-based game software [...] that has been developed with the intention to be more than entertainment"*. However, commercial entertainment games can be used in educational settings as well. For example, *SimCity* can teach about urban planning and *Civilization* or *Age of Empires* can be used for teaching history (Charsky and Mims, 2008; Prensky, 2007; Squire and Jenkins, 2003). Breuer and Bente (2010) even hypothesizes that any game that is used in an educational setting will implicitly become a serious game.

In an effort to unite the different understandings of serious games, broader definitions have been presented. Susi et al. (2007) define serious games as *"(digital) games used for purposes other than mere entertainment"*. The definition by Klopfer et al. (2009) sounds similar, referring to serious games as *"games with a purpose beyond play"*. This form of definition will be used in this thesis to allow for an open and unrestricted consideration of serious games.

4.1.2. Related Terms

Even though serious games are a relatively new field, a set of related concepts exist. Some of them overlap with serious games to a certain extent but others have different meanings. Breuer and Bente (2010) analyzed the relations of various learning-related concepts such as edutainment, e-learning and digital game-based learning, showing that the terms are closely related and nested within each other (see Fig. 4.1). This view is in line with the stricter definitions of serious games in that they are primarily intended for learning purposes. Looking at the full range of serious games application areas (see Section 4.3), the area of serious games should fill a larger space apart from the concepts related to learning. In order to give a better overview of what serious games are and what they are

not, the most relevant and commonly misconcepted related terms will be presented in the following.

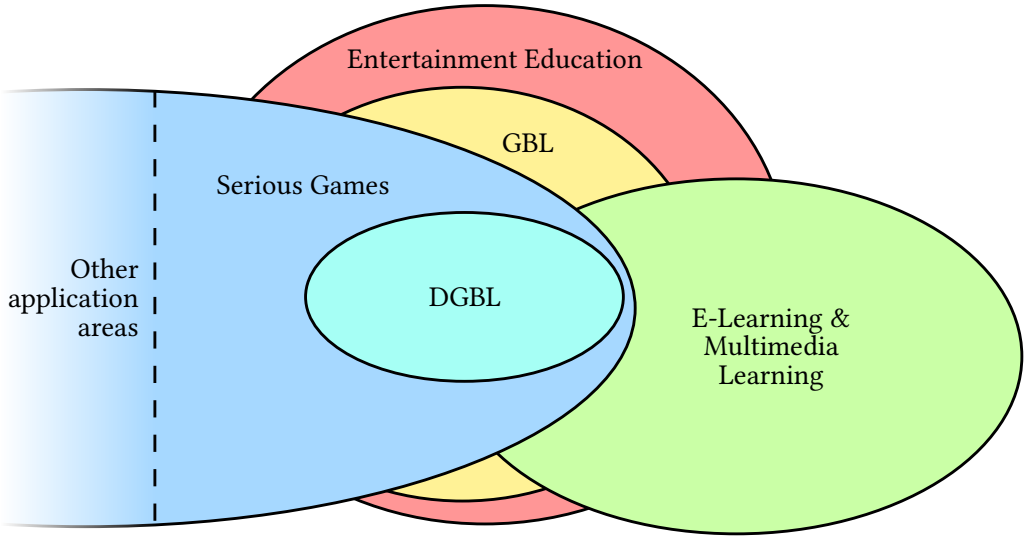


Figure 4.1.: Classification of serious games and related concepts in the educational sector. Source of the original image: (Breuer and Bente, 2010)

Edutainment

Edutainment — meaning "education through entertainment" — is a concept that closely relates to the original definition of serious games (Michael and Chen, 2006). It originated in the 1990s at the time when personal computers were becoming popular and was usually related to digital applications. Edutainment was used almost exclusively in educational settings with students as its target group. However, it lacked certain aspects that are incorporated into modern serious games. As the main emphasis was put on the education part, the entertainment was often left behind. Both parts were plugged together, but they were not deeply connected (Charsky and Mims, 2008; Squire and Jenkins, 2003; Van Eck, 2006). This resulted in mere "drill-and-practice" models and simple memorization tasks (Squire and Jenkins, 2003). Many serious games, on the other hand, are designed to engage players just as commercial entertainment games do, and at the same time use this engagement for transporting the serious content to their players (Breuer and Bente, 2010; Susi et al., 2007). Nowadays, the term edutainment is not commonly used anymore but has been superseded by serious games or other recent concepts.

Gamification

The concept of gamification originated in 2008 and since then has steadily increased in popularity (Deterding et al., 2011). This development draws from the fact that more and

more parts of our daily life — including work — are blended with game elements, just like games shift into business areas (see Section 2.5). Deterding et al. (2011) defined gamification as *"the use of game design elements in non-game contexts"*. Instead of implementing full games, only a few distinct game elements are applied to tasks that otherwise would not be considered as games. As such, gamification can be clearly connected to the *ludus* part of the play continuum (Caillois and Barash, 1961). Compared to serious games, however, gamification approaches only implement parts of full games (see Fig. 4.2). Elements that can be frequently found in gamification applications include achievement and score systems, like in *Foursquare* (Ebling and Cáceres, 2010). The goal of adding such mechanics is to make tasks more interesting that otherwise might be boring or repetitive. By adding extrinsic motivators to those tasks, users — especially those that correspond to the *achiever* type by Bartle (1996) — will get motivated to continue. However, gamification only covers a small part of the game spectrum. The whole part of play as a free activity that takes place in a magic circle is not considered. On the contrary, gamification is mostly tied to real life problems or tasks, often with a pervasive approach (Deterding et al., 2011). This is one reason why the trend of using more and more gamification elements is also seen sceptically. For example, Lucero et al. (2014) argue that experiences should include more playful elements rather than the purely gameful elements seen in gamification. This can also serve as an argument for using more serious games instead of "gamified" applications, as only games can offer the full experience of engaging players.

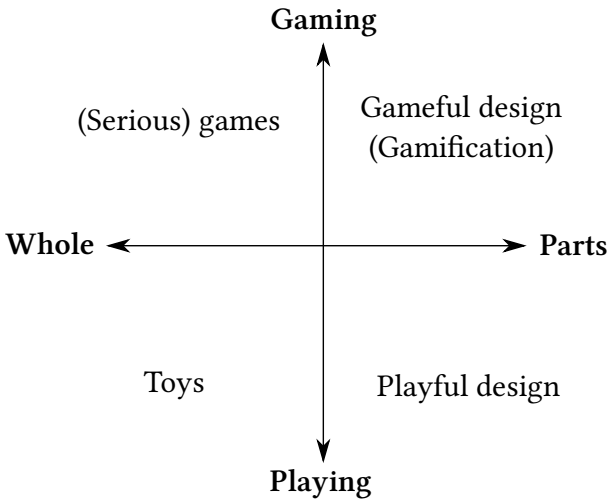


Figure 4.2.: Orientation of serious games and gamification according to Deterding et al. (2011).

E-Learning

E-Learning is often linked to the area of serious games, sometimes even mistakingly used as synonyms for each other. It refers to *"computer-enhanced learning, computer-based*

learning, interactive technology, and commonly, distance learning" (Hodson et al., 2001). Basically all digital applications that are made for enhancing the learning experience can be seen as e-learning, including media formats such as texts, pictures or videos (Clark et al., 2011). This includes tools for interactive lectures such as the *MobileQuiz* by Schön et al. (2012, 2015). As such, learning games as an area of serious games form a part of e-learning, but not the other way around (Breuer and Bente, 2010).

(Digital) Game-based Learning

Game-based learning (GBL) refers to using games for educational purposes. This is similar to some definitions of serious games, and both terms are indeed used synonymously (Corti, 2006). However, this view is not shared by others that refer to GBL as a subset of serious games (Prensky, 2007; Susi et al., 2007). When looking at digital media such as computer games, digital game-based learning (DGBL) can be seen as a special form of serious games that are focused on education in schools (Sawyer and Smith, 2008; Van Eck, 2006). Prensky argued that this is not the only application area, though. DGBL can also be used to educate adults, it can be used in business contexts for education and trainings, and it is even used in military scenarios (Prensky, 2007). Then again, he agrees that children are the most important target group for DGBL approaches. As the current generation is used to interact with digital technologies everywhere and always, children are *"native speakers"* in that respect. Consequently, education should not neglect this fact and actively work with approaches children are used to which explicitly includes games (Prensky, 2007). DGBL thus acts as a successor to edutainment without keeping up the mistakes that led to its failure (Corti, 2006; Van Eck, 2006).

4.2. Reception of Digital Games

As mentioned in the introduction of this chapter, there seems to be an inner conflict in using games for serious matter such as learning and training. The term serious games itself is cause for discussions, because — using strict definitions — games must not involve serious activities, and if they do they are no longer games (Breuer and Bente, 2010; Michael and Chen, 2006). Furthermore, digital games repeatedly have been receiving negative press for being a waste of time or even to have negative impacts on the players' lifes.

Prensky (2007) gives a possible explanation for these conflicts. He separates fun that games create into two components: enjoyment and amusement. Enjoyment means being engaged into something and drawn into an activity without any external trigger. Amusement, on the other hand, denotes pure leisure that is frivolous and does not follow any meaning. These two components are both used by opponents and proponents of serious games: Opponents of serious games might only see the latter, thinking that such applications only pose a distraction without using the motivational aspects that result out of the felt enjoyment (Witherspoon and Manning, 2012). As games are very closely related to pure amusement, there is also the belief that they cannot be used for something meaningful at all. If considering the enjoyment part, however, play and games go well together with learning. After all, children learn many things by just playing. Bisson and Luckner

(1996) also note that fun is an important part when learning, because it provides a relaxed atmosphere where learners are willing to learn. Salen and Zimmerman (2004) describe pleasure as *"the experience most intrinsic to games"*. As a consequence, serious aspects would be necessary part of games that build up on play (Schrammel and Mitgutsch, 2009). Current trends also show that games and work life are being blended more and more when games become work and vice versa (Michael and Chen, 2006). Still, it is important to consider the potential negative effects of games when working with serious games, because they only have a chance of being successful if they are accepted by players, instructors and society in general.

The following remarks do not come with a claim of completeness. For example, addiction problems with games are a severe problem for a small set of players, and the correlation of violent behavior and violence-glorifying games are still subject to studies. However, for the course of this thesis it is assumed that as long as games are played in responsible doses there should not be any major negative consequences.

An area where games are seen with especially skeptical eyes is the educational sector. A common belief is that games and learning performance are directly opposed, that is, games are actively suppressing "serious" matter such as learning. In fact, entertainment media in general are considered as negative for the students' performance and their attitude towards learning, as stated by Rideout et al. (2010). Specifically, digital games with their visual attractiveness and instant feedback can spoil learners from using other traditional media such as school books (Walsh, 2002). However, this could also be seen as an indication that media usage in schools is just lacking behind current trends. Anand (2007) found out that playing digital games will have negative impacts on academic performance because it will take away time from useful tasks such as studying. Mitchell and Savill-Smith (2004) came to similar results, showing that regular players had a lower interest in school and that students that performed below-average were more attracted to play games. The cause for these correlations is not clear, though. Do students play more games because they perform poorly in school, or do they perform poorly just because they play games? After all, playing games can be seen as as a regular leisure activity. Wack and Tantleff-Dunn (2009) call games a *"healthy source of socialization, relaxation, and coping"*. As such, games would fall into the same category as working out which also takes away time from studying but is generally not seen as a waste of time.

Apart from negative effects, digital games are also linked to certain beneficial aspects. Looking at the educational sector again, regular players were found to show improved problem-recognition, better self-monitoring and problem-solving skills, longer attention spans (Navarro et al., 2003) and a better retention of knowledge (Squire and Jenkins, 2003; Susi et al., 2007). Especially, multiplayer games could improve social skills — including the abilities to collaborate and to communicate — and shared decision-making, according to Ellis et al. (2006). Additional skills fostered by online games are strategic planning and thinking, as Kirriemuir and McFarlane (2004) found out. Such games can also lead to an improvement in literacy skills, because a lot of reading and writing is usually required (Squire and Steinkuehler, 2005). Games in general are also able to foster motivation in a certain topic. For example, the computer games *Civilization III* and *Revolution* have been used successfully in history courses, because they approach historic events in a playful

and tangible manner (Squire and Jenkins, 2003). Regular players also have the benefit of getting in touch with computer technology regularly which can give them an advantage in both their education and business life (Beck and Wade, 2004; Schweingruber et al., 2001).

Not being connected to any specific application sector, games can have other beneficial aspects, too. A skill that is often associated with playing digital games is spatial thinking. By playing simple games such as *Tetris* or more complex 3D games, players can improve their spatial thinking skills. Experiments showed that players of those games showed better skills in mental rotation tasks than participants who did not play (De Lisi and Wolford, 2002; Susi et al., 2007). While these improvements might seem abstract and not suitable for daily use, they can very well be used for specific tasks. For example, medical students were found to perform better in surgery tasks after playing respective games (Enochsson et al., 2004; Rosenberg et al., 2005). Also, driving students where found to perform better if they regularly played racing or action games (Backlund et al., 2006). Another set of skills that is often related to playing games consists of cognitive skills to quickly detect and track objects in a scene. This is especially linked to fast-paced action games where players have to react quickly. For example, in FPS games, players have to quickly distinguish between friends and foes and aim accurately at their targets. Studies showed that players of such games showed higher skills in visual search tasks than non-players (Castel et al., 2005; Clark et al., 2011; Colzato et al., 2013). Green and Bavelier also looked at visual skills of players. Two consecutive studies came to the result that regular gamers show higher levels of attention and concentration when performing visual tasks (Green and Bavelier, 2006, 2007).

4.3. Application Areas

Historically, serious games were restricted to the field of education (Abt, 1970). From the point on when they have been known to a broader audience, however, they have spread to a variety of application areas. This includes the intended usage scenario of the games as well as the sector in which they are really used. In an effort to describe all commonly used areas, Sawyer and Smith (2008) proposed a categorization of serious games regarding their audiences and purposes. Not all of them are being used at equal shares: Ratan and Ritterfeld (2009) analyzed over 600 serious games regarding their audiences. They found out that education is the dominant sector with 63 percent of the games falling into this category, followed by 14 percent for social contexts, 10 percent for professional training, 8 percent for medical training and health care, 5 percent for military purposes and 1 percent as marketing or advertising tools. Djaouti et al. (2011) state slightly different numbers especially for the time since 2002. Out of over 2000 analyzed games, education only forms the second largest area with 25.7 percent and advertising has the biggest share with 30.6 percent. Based on these categorizations, this section will give an overview of the most common application areas of serious games, sorted by their audiences (Blumberg et al., 2013; Djaouti et al., 2011; Ratan and Ritterfeld, 2009; Sawyer and Smith, 2008). Along with the overview, related studies and game examples will be presented.

4.3.1. Education

Despite the skepticism that games and learning are opposite concepts that cannot be combined (see Section 4.2), the educational sector has the biggest share in the usage of serious games (Ratan and Ritterfeld, 2009). There are multiple reasons why they are used so much in education. First, learning games draw from the fact that the underlying form of play serves as a training platform (Shaffer and Gee, 2012). As already discussed in Section 2.5, play offers players the possibility to try out certain aspects in an isolated space without having to fear serious consequences. This enables trial-and-error approaches, an important factor for learning (Thai et al., 2009). According to Schell (2008, p. 443), classic education also fulfills all necessary requirements of a game — including rules, goals and challenges — making it perfectly applicable to be mapped to games. Second, games are interactive. In contrast to books, they can adapt to the players' performance (Klopfer et al., 2009; Wendel, 2015). For example, by letting players choose different paths through the game, each one can work on an individualized set of tasks. Adapting to the players' skill levels also helps to keep them in the flow channel (Admiraal et al., 2011; Chen, 2007). This interactivity is not limited to games, however. Potentially all digital e-learning applications can implement such features. What makes games different from those applications is the third main reason: games are fun (Breuer and Bente, 2010). As discussed in Section 3.3.2, games employ a whole set of features that create motivation and that let players enjoy them. Gee (2003) adds that collaboration or competition are important motivational factors for learning games as well.

Klopfer et al. (2009) note that players *"regularly exhibit persistence, risk-taking, attention to detail and problem solving skills, all behaviors that ideally would be regularly demonstrated in school"*. The inclusion of games in curricula seems to be even more important when comparing teaching methods and learner styles. Schools largely still employ techniques that base in the industrial age (Thai et al., 2009). Following a teacher-centered approach, teaching methods are often passive and restricted to *"learning how to memorize"* (Gee, 2003; Stapleton and Taylor, 2003). Opposed to this are students that are growing up with interactive digital media deeply connected to their daily routine, thus named *"digital natives"* by Prensky (2007, p. 52) and others. He suggests to employ learner-centered methods that set learners in a more active role. Using games obviously is one possibility to do that, but non-gaming based methods such as the *flipped classroom* can be used as well (Bergmann and Sams, 2012).

Educational games are not limited to the use in curricula alone, however. For example, the game *Study-Town* presented by Bohn et al. (2014) aims at teaching the local customs of the German culture, including the comparably complex system for waste separation, to exchange students coming to Germany. Many studies — accompanied by meta reviews like done by Young et al. (2012) — that evaluated the applicability and effects of games in various educational contexts have been carried out, as presented in the following.

Studies with Positive Outcomes

Several studies indicate the effectiveness of serious games in educational settings (i.e., schools). Regarding the topic of mathematics, comparative studies showed that students that played learning games both got better results (Kebritchi et al., 2010) and were more motivated to do homework (Young et al., 2012) than students who did not play. Ke and Grabowski (2007) additionally found out that collaborative gameplay in math games is more effective than playing alone when measuring motivation and interest of players. Similar results were observed by Barab et al. (2009) in a study done in science classes with *Quest Atlantis*. Out of two groups — one playing the game and one that worked with traditional lecture materials — students from the gaming group performed better in a following test even though the other group seemed to be more focused. Barab et al. suggest that the active exploration possibilities were responsible for the positive outcome and thus should be incorporated more frequently.

Other studies focus on history classes. Especially the game series *Civilization* has gotten considerable attention. Squire and Jenkins (2003) used *Civilization III* for teaching history in schools. While the study had a positive outcome with an increased knowledge of maps, time lines, and historical terms, Squire and Jenkins also observed that teachers are required for guiding students and to discuss the experiences. The results are confirmed by Lee and Probert (2010) who conducted a similar study with the same game.

Concerning language learning, results of studies are among the most positive outcomes. In their comprehensive review of learning games and their results, Young et al. (2012) rank this topic as the most promising. They argue that games are well suited for language acquisition because they are able to set players in believable scenarios where they experience different locations and cultures by providing virtual worlds that either can be entered alone or collaboratively. One such virtual world is *Active Worlds* that has been successfully used by Toyoda and Harrison (2002) for second language training. Ranalli (2008) used *The Sims* supplemented by web-based learning material for language training and especially vocabulary training, again with positive results. Another commercial entertainment game that has been used for this purpose is *Word of Warcraft*. It can be used as a tool for second language acquisition because it fosters social interaction and collaboration in a *"motivating, goal-driven, and learner-centered environment"* (Peterson, 2009; Thorne and Magnan, 2008). Another comparative study on language learning has been conducted by DeHaan (2008). He let one group of students at a Japanese university play a learning game for language acquisition while a second group only got to watch the players. The surprising result — confirmed in a follow-up study (DeHaan and Kono, 2010) — was that after the gaming sessions students from the observing group showed significantly better skills than the players themselves. Young et al. (2012) argue that is due to the higher cognitive load the players had to face in comparison to the bystanders.

Studies with Negative Outcomes

Not all studies on the usage of serious games in education come to positive conclusions. Some do not see an improvement of using games over regular teaching sessions with

teachers, like Annetta et al. (2009). While they did not see an improvement in the learning outcome, they at least observed that students from the gaming group showed higher engagement in the subject. Similar to the work done by Squire (2005), Moshirnia and Israel (2010) used a modified version of *Civilization IV* for teaching history to students. They reported that players mostly ignored the information that was added to the game. As a consequence, students who played did not perform better than those who got the information via PowerPoint presentations. Akkerman et al. (2009) observed similar results with another game and came to the conclusion that players do not pay attention to contents if they are not relevant for playing/winning the game. In other cases, studies produced more negative results. Harris (2008) conducted a study where a group of students played *Web Earth Online* while the other group was only instructed by a teacher. Not only did the game not have any beneficial outcomes, but Harris observed worse results in the learning outcome with students from the gaming group.

Three main reasons have been identified why games are not successful when used in educational scenarios. First, if games use a flawed game design they will probably not be successful from the start (Baek, 2008). If they are not fun or do not transport the educational content, players will not have a benefit from playing. Game developers can circumvent this problem by working together closely with the intended target groups (Christel et al., 2014). Second, teachers have to get used to the new opportunities before accepting and really using them, as Bourgonjon et al. (2013) point out. As long as teachers see games as a waste of their valuable teaching time, games will not be used on a wide basis (Devlin-Scherer and Sardone, 2010). This causes an even greater drift of traditional teaching methods used in schools to the lifestyle of today's *"digital natives"* (Prensky, 2007). Then again, Millstone (2012) reports that the majority of U.S. teachers agree that video games have beneficial features for the classroom, and according to the Entertainment Software Association (2015), 63 percent of the U.S. parents see games in general as a positive part of their children's life. Last, games should not be seen as the one and only way how to educate. Squire (2005) argues that games that are used in an educational context should always be accompanied by instructors either directly during the game sessions or in following discussions. Instructors should also keep in mind that not all games are suitable for all learner types and that the outcomes might largely differ depending on the scenario (Corti, 2006; Van Eck, 2006). Devlin-Scherer and Sardone (2010) add that the usage of games in curricula should not be overworked. Otherwise, playing will become a tedious obligation, and games will lose one of their key features, namely the motivational aspect. As with many new technologies, serious games in education should not be seen as a panacea for all shortcomings. On the contrary, they should be seen as another tool that can be used in addition to the existing ones to make learning more effective or to reach more types of learners.

4.3.2. Social Contexts

According to Ratan and Ritterfeld (2009), serious games with social contexts form the second large group of the different application areas. Such games are not meant to explicitly teach a certain aspect. Instead, they are used to call attention and raise interest of play-

ers to certain topics. This includes the areas of journalism, politics or civil engagement. According to Bers (2010), games concerning civil engagement can be further separated into four categories, namely civic knowledge, civic conversations, civic attitudes and civic behaviors. Especially the last two categories can not only be found in dedicated serious games but also in commercial entertainment games that build up on social aspects. For example, in *Word of Warcraft* players benefit from working together or from trading goods between each other. As such, many massively multiplayer online games (MMOGs) form virtual societies and can be seen as a playground for modeling social aspects in the real world. Another example is *SimCityEDU*, an educational variant of the commercial game *SimCity* that teaches players how to build and manage a city.

A large number of games about social contexts are created by following journalistic principles. These games address current events or topics and are also called *Newsgames* (Bogost et al., 2010). The main goal of them is to let players critically think about the respective topics. These include dealing with terrorism (*September 12th*), the crisis in the Middle East (*PeaceMaker*), poverty/hunger (*Darfur is Dying*, *Spent*, *Ayiti: The Cost of Life*), child labor (*Sweatshop*) and refugees (*Frontiers*). Another recent example is the commercially successful game *This War Of Mine* that lets players experience a war from the perspective of regular civilians, acting as an antithesis to war games such as *Call of Duty* or *Battlefield*. What most of these games have in common is that loosing the game is an integral part of the game. This is due to the reason that the handled topics are usually not solved in the real world, too. By failing the game, players are shown the difficulties or even hopelessness of the situations, making them think about the topics (Marsh and Costello, 2012). Due to experiencing the situations in an interactive manner, however, games have the potential to have a greater impact than reports in newspapers or on TV.

Even though there is a multitude of games with social contexts available — indicating that the concepts work — the actual effectiveness of them is not yet fully proven (Bers, 2010). A reason might be that the learning outcome is not as specific as with educational games. While the latter allow for tests that measure the outcome objectively, the effects of the former can often only be assessed by asking players for their subjective opinion how the game changed their view on the respective topic. Furthermore, players (i.e., test subjects) cannot be accessed as easily as in educational settings.

4.3.3. Corporate Applications

Serious games in the corporate sector can be seen from two perspectives, namely an external and an internal one. The former refers to games that are made by companies for potential customers. They usually have the intention to attract interest in the company or a certain product for marketing and advertisement purposes. Consequently, they are called *advergames*. Games for internal use, on the other hand, are primarily targeted towards employees. Such games are closely related to the ones in educational contexts and will be examined in more detail in the following.

The application areas education and corporate share many properties and have undergone similar evolutions. Early applications focused on simple instruction-based techniques by using films or lectures and had more similarities with e-learning applications

than with games (Corti, 2006). Like with educational applications, these passive and linear approaches did not engage users. Consequently, they were not effective and did not address the interests of the younger generation (Michael and Chen, 2006; Prensky, 2007). Serious games, on the other hand, promise to engage players and to be an effective tool for learning or training (Ritterfeld and Weber, 2006). According to a study by Faria and Wellington (2004), 30 percent of 1,085 participants claimed they had used some kind of business simulation which shows the relevance of respective applications and games. In contrast to the educational sector, however, games for corporate use do not mainly focus on explicit learning but on training and simulations. They are based on early simulation applications (e.g., flight simulators) which — enhanced with game elements — became a separate field of serious games (Zyda, 2005). However, the border between learning and training is not clearly defined. Many common aspects can thus be found both in educational and corporate games. Then again, the audiences for both areas are clearly different. Active areas where games for corporate use are being developed nowadays include marketing, financial management, project management, knowledge management, risk management, and microeconomics (Dill, 2013, p. 342). A well-known example for such games, as stated by Goodwin and Franklin (1994), is the *Beer Game* which is used to learn/train operation management for a company.

Several traits make serious games a useful tool for corporate use. (Prensky, 2007, p. 204f) lists three reasons. First, games appeal to the generation of *"digital natives"* that now enters work life. Second, games help to motivate players as learning content on its own or pure simulations tend to be boring. Last, when aiming for high productivity, games can be an effective learning/training tool for employees. Michael and Chen (2006) argue similarly, stating that games can drastically lower training expenses and be more effective than traditional techniques. However, corporate games are not limited to pure training purposes. For example, games can help employees to find their roles in a large corporation, or companies can use games for the assessment of new job applicants (Corti, 2006). The *SERIOUS PLAY*[1] methodology by LEGO is another approach how to combine playful experiences with the daily work life.

Regarding the profit, corporate training yields the highest potentials for serious game developers (Michael and Chen, 2006; Stapleton, 2004). Just like with games in education, however, the use of such games is still seen skeptical by decision-makers that have to decide to invest in a "leisure" activity with uncertain outcomes (Stapleton, 2004; Susi et al., 2007). But with more of the *"digital natives"* coming to leading positions, corporations started to see the relevance of game-based approaches. A recent trend for bringing more game concepts to business life is the use of gamification (see Section 4.1.2). Large corporations such as SAP incorporate more and more gamification ideas into their internal and external business processes, leading to a deeper connection of work life and gaming (Kumar, 2014; Yolton, 2013).

[1] `http://www.lego.com/en-us/seriousplay`, visited on 29.09.2015.

4.3.4. Health and Fitness

Health care and medical treatments represent diverse fields for serious games. The reasons for them being used are similar to the use of corporate or educational games: Compared to traditional treatments, games can be cheaper, more effective or even both (Michael and Chen, 2006). Games exist for various health scenarios: Some are being used as preventive measures for non-patients, some are used in therapy for patients, and yet others are promote generic topics such as fitness to players (Hardy et al., 2014; Wattanasoontorn et al., 2013).

A major part of serious games in the health sector deal with the actual treatment of various conditions or diseases. When working with physical conditions such as rehabilitation after strokes, games mainly act as motivational tools to perform repetitive tasks (Wiemeyer, 2014). Due to their interactive nature, however, games can also be designed to adapt to the players' conditions to increase the effectiveness of the training and to keep players in the flow channel (see Section 3.3.1) (Hardy et al., 2014). When used to treat mental conditions such as alcohol addiction, phobia or post-traumatic stress disorder, games are often used for their simulation capabilities. Several commercial games have been adapted to treat a fear of snakes, spiders or of driving cars (Michael and Chen, 2006). A regular exposure to well-known situations can also be used to get rid of unwanted behaviors like an alcohol addict that subconsciously reaches for alcoholic drinks without really noticing it (Vollstädt-Klein et al., 2010). Another often cited example of therapy games is *Re-Mission*. It has been successfully used in cancer therapy, even though it only accompanies a regular treatment (Dill, 2013, p. 344; Lampert et al., 2009). Here, a factor of games comes into play that is neglected or even undesirable in other application fields of serious games: pure leisure. Especially in cancer therapy, games target to distract the players from their conditions and to relax them from otherwise stressful therapies (Kato, 2010).

Apart from actual treatment, serious games are also used as preventive measures in health care. This can precede regular treatment, as done by Boendermaker et al. (2015) who used a game to inform adolescents about alcohol and drug abuse before they actually need therapy. *Fatworld* is another game with a concept similar to *The Sims* that was used to inform children about healthy nutrition and the dangers of obesity.

A related recent trend in games for health are *exergames*. Such games base on physical exercises (Göbel et al., 2010). Therefore, they usually require additional input controllers that are able to track the players' movement (Kato, 2010; Michael and Chen, 2006; Thai et al., 2009). Devices include remote controllers, dance pads, Nintendo's *Wii*, Microsoft's *Kinect* or Sony's *Move* controller. With the support of such big companies, the respective games are becoming more popular and widespread. A well-known example is *Wii Fit*. Games like *Dance Dance Revolution* or *Dance Central* started as pure entertainment games but are now also used as explicit exergames (Baranowski et al., 2008). According to Mhurchu et al. (2008), playing exergames is comparable to regular workout sessions. Studies that examined the use of exergames in U.S. schools found positive influences on children's health (Dill, 2013, p. 344; Kato, 2010; Thai et al., 2009).

While there are many indications that games for medical treatments and health care are effective, more studies should be done to get more in-depth results (Wiemeyer, 2014). While such games have positive effects on players during the game sessions, the long-term influences are not fully understood yet. Baranowski (2014) argues that games have to put more emphasis on motivating players for longer periods to prevent falling back to unwanted behaviors after a short amount of time, similar to the "yo-yo effect" often present with diets (Brownell et al., 1986). This fact is not only an important consideration for health games but for any serious game.

4.3.5. Military Applications

Using games for military purposes has a long history. It starts with board games like chess — an abstraction of a battlefield — and other war games and goes up to the realistic combat simulations of today (Michael and Chen, 2006). Computers greatly improved the possibilities to model realistic simulations and thus found their way to military applications soon after their invention. Nowadays, computer-aided games are used for mainly two purposes, namely training and recruitment (Stapleton, 2004).

Using simulation-based applications for training purposes dates back to early flight simulators (Buckley and Anderson, 2006; Michael and Chen, 2006). They were built so that soldiers could train flying without risking expensive equipment or even their lives. While these simulators had few or no game elements, these aspects were added over time to make the applications more immersive and engaging (Zyda, 2005). Nowadays, computer-based training games are used frequently. For example, the game *Saving Sergeant Pabletti* is stated to be used by over 80,000 recruits of the U.S. Army each year. *Tactical Iraqi* is another game that was used to prepare soldiers for a mission in Iraq by teaching them language skills (Losh, 2006). A study by Surface et al. (2007) showed that the game was indeed effective in increasing the Iraqi Arabic skills of players. Losh (2006) presented another game that is not related to training activities but to the treatment of post-traumatic stress disorder. In *Virtual Iraq*, combat veterans are confronted with unpleasant situations they experienced during their duty. The game is accompanied by traditional therapy and has proven to be effective like similar games in the regular health sector (see Section 4.3.4) (Losh, 2006). It was derived from an existing commercial entertainment game. Such adapted games are enhanced with simulation elements to make them more realistic. However, Prensky (2007) reports that most simulations have to be simplified to favor motivation over realism and to make the game fun to play. As with serious games in general, players will only keep playing and learning if they enjoy the experience.

A second large sector within military applications are games for recruitment. Among them is what is considered to be the first largely successful serious game, namely *America's Army*. After its release in 2002 it built up a community of 4 million players with more than 17 million downloaded copies in only two years (Michael and Chen, 2006; Prensky, 2007). Its initial purpose was to introduce the basic principles of being a soldier to people who were interested in joining the U.S. Army. In contrast to pure entertainment war games such as *Battlefield*, the game puts an emphasis on teamwork, for example by punishing

spontaneous solo actions. Later it also became a training tool because it modeled the soldiers' basic training so accurately (Zyda, 2005).

4.4. Summary

The term *serious game* as it is understood today was introduced in the 1970s by Abt (1970). At first, it explicitly referred to games that have a clear educational focus. Games were seen as a mere tool to make tasks fun that otherwise would be boring. While this sight is still present in some definitions, others allow serious games to be fun in the first place, saying that they are *"games with a purpose beyond play"* (Klopfer et al., 2009). Such broader definitions allow serious games to be fun up to a point where players do not even realize that they play a serious game. Due to the disunity of the definitions, related concepts were proposed under different names while other concepts are mistakenly confused with serious games. Digital game-based learning, for example, denotes games that are used for learning and thus can be seen as a synonym of serious games. A negative and ultimately unsuccessful concept was edutainment that put too much focus on education, leaving the entertainment part behind. The recent trend of gamification, on the other hand, is becoming more and more successful by interweaving game elements and daily tasks in both leisure time and work life.

Serious games only became known to a broader audience in the early 2000s. Since then, however, they have spread to many application fields where they have been successfully deployed in various scenarios. The available games can be categorized by their audience and their purpose (Sawyer and Smith, 2008). The educational sector is among the biggest audiences. By introducing game-based approaches into curricula, the current generation of the *"digital natives"* can be better reached as with only traditional, teacher-centered methods. This group of adolescents and young adults also constitutes the biggest target group of entertainment games, making it the preferred audience for serious games. However, serious games are also used for different purposes/audiences. Games with a social context, for example, do not explicitly teach but are intended to let players critically think about problems. Apart from the educational sector, serious games are also successfully used in corporate and military areas for training and recruitment. Finally, they are used in the health sector as part of medical treatments or as preventive measures.

A lot of studies have been conducted that examined the outcomes of using serious games in various scenarios. Studies can be found in all application areas. The majority, however, was conducted in educational settings (mainly schools) for different topics, including history, language acquisition and maths. Many studies come to the conclusion that serious games indeed have a positive influence on both the motivation and the learning outcome. Similar studies with games in the health sector also attest an increase in treatment effectiveness. Then again, not all studies come to such conclusions. Summarizing the respective results, a set of common aspects can be derived that prevent serious games from being successful. Like with many innovations, the use of them should not be overdone. For example, serious games in schools should not just replace traditional lectures, but they should enhance the existing set of teaching methods. For serious games to be

used in supervised settings altogether, however, the supervisors themselves (i.e., teachers, instructors, therapists, …) have to accept games as valid tools before they use them with. While such a paradigm shift has started as more of the "digital natives" have entered the roles of instructors, it will still take some time until games are largely accepted in society. A way how to ease the entry to using serious games is to give instructors more freedom in the game design process. On the one hand, this includes putting more effort into well designed games that take into account the needs of supervisors and players. On the other hand, instructors should be allowed to better adapt the available games to their need, for example by changing the included learning material to their specific curricula. Serious games will become more effective and more frequently used only if all these shortcomings are removed.

Part II.

Serious Games Creation

5. Serious Game Design

This chapter covers the topic of creating the design for a serious game. It first presents selected background information on games in general and how they create engagement in players — a property that is essential for serious games. The actual design process is similar to designing entertainment games but differs when it comes to the integration of the serious content. This chapter concentrates on these differences and presents solution strategies how to create serious games. It gives an overview of all the main tasks a game designer is involved in. Beginning from coming up with an initial idea for a game, the steps of defining constraints for it and adding suitable game mechanics are described. Finally, ideas are presented how to organize the whole development process with a focus on creating serious games that follow a *holistic approach*, tightly integrating components that leave neither the gaming part nor the serious content behind.

5.1. How to Design a Serious Game

There are two main reasons to create a serious game for a certain application. First, games in general create motivation in players to proceed in the game, to beat the highscore, or to be the best player in an online game. Millions of players prove this fact each day when looking at the "consumption" of digital entertainment games. Developers of serious games can use these motivational aspects for other purposes than mere fun and entertainment. This does not mean that serious games should not be fun. The opposite should be true: They should not be less fun than any pure entertainment game. This, however, might not be easy to achieve. Game designers, programmers, artists and experts have to work together throughout the whole development process. Moreover, in many cases developers of serious games have to cope with limited budgets. This may result in a suboptimal consideration of the fun parts of the game, for example if there are no resources for hiring professional game designers or artists. Figure 5.1 gives an overview of all the involved parties that should work together in the development process of serious games. Having an active communication between the different groups is a key aspect of producing meaningful games (Khaled and Ingram, 2012). This scheme is very similar to entertainment games, with the exception that with serious games domain experts are included who deliver the serious parts of the game. Game designers have a central part in the creation process. They are the ones who decide what game to create and how to combine characterizing goals (i.e., the serious parts) and entertainment parts. While small details can still be changed throughout the development process, the big decisions — game genre, main story or game world — have to be set in the first phase. It is the game designer's task to create a design and make sure that the whole team works along it over the wntire development phase.

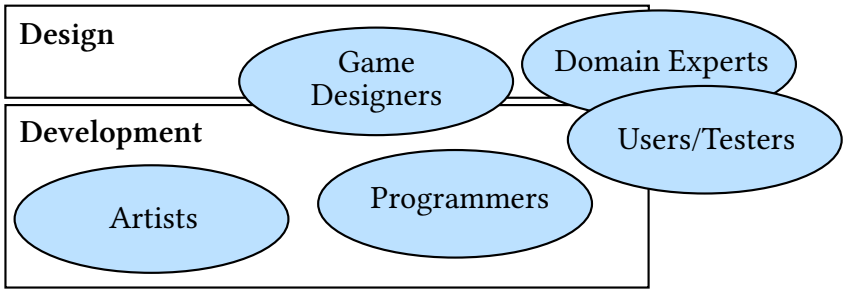


Figure 5.1.: Involved parties in the development process of serious games.

When comparing the game design process of pure entertainment games and serious games, there are two main differences. First, as mentioned above, there is an additional party involved in the process, namely the domain experts. Game designers have to cooperate with them in order to create a meaningful game. Second, a serious game always has some goal or message that should be transported to the player in addition to the fun part of the game. Designers of serious games should take great care on how to connect both parts. Apart from these two aspects, most of the known techniques for game design used for building pure entertainment games can be applied as well. Nevertheless, the basic principles of the whole process will be presented in this chapter with a focus on the differences and the integration of the characterizing goals.

The following Section 5.2 will give an overview of the motivational elements that make games so appealing and interesting to their players. Section 5.3 then presents the approach how to come up with initial concepts for a game and how to build the overall project structure. Section 5.4 examines the integration of the "serious" and "fun" parts of a serious game. In Section 5.5, a more detailed view on the different elements that can be found in many games follows.

Overall, there are many open questions in this chapter, but because of the wide field of game design, there is not only one right answer. Therefore, the chapter provides just an overview, raises questions and points out possible strategies by referring to more in-depth articles and books.

5.2. Game Characteristics

Playing a good game is fun. Prensky (2007, p. 106) even calls digital games *"potentially the most engaging pastime in the history of mankind"*. Games motivate players by including a variety of different characteristics, as presented in Section 3.3. If this motivation does not come from an external source but just from the game itself, it is *intrinsic motivation*. Otherwise it would be *extrinsic motivation*. So when serious games are used as motivational tools, is it intrinsic or extrinsic motivation they are creating? The answer is not straightforward. When used mainly as a motivational tool for otherwise boring or repetitive tasks, a serious game provides extrinsic motivation to its players. For example, a learner might not have a high intrinsic motivation to study for the next exam just by

reading books. She might, however, be interested in playing a game where she competes against other students while learning for the exam. As soon as the exam is over, the need for learning is also over, and the player thus might stop playing the game. This is therefore extrinsic because the game is just regarded as a tool that helps to accomplish a certain goal. But not all serious games have to follow this approach of "being just a tool". Games like *Civilization* or *Age of Empires* are good examples. These games deal with historic events in a playful manner, and they were successfully used in the classroom for teaching history (Squire and Barab, 2004). There are even people who state that the most they learned about history was by playing these games. The primary motivation to play these games, however, was most likely not to learn for the next history lesson but just to have fun. In such a scenario, the game can help to foster intrinsic motivation for the learning content, because players then want to know more about a certain topic that was presented in the game.

Even though games act as motivational tools, they do not appeal to every player in the same way. Some players like action games, others prefer real-time strategy games. Some like to play simple casual games on their mobile devices while others invest a lot of money to have the fastest computer to play the most demanding and modern 3D games. There probably are as many different opinions what the best game should look like as there are players. This does not only depend on the age and gender of a player, but these aspects certainly play a big role. Male and female players prefer different aspects in a game, and children play other games than teenagers, adults or the elderly. When a game displays males as muscular heroes and reduces females to sexually appealing and passive objects, the game will most likely be attractive to a male-dominated audience. Furthermore, it might even influence adolescents in their attitude towards gender roles. Boys might suffer because they cannot physically compete with the depicted heroes whereas girls might fall into the role of passiveness in the real world (Miller and Summers, 2007). In addition to such demographic factors, there are different psychographic models that differentiate between player types. A mentioned above, Bartle (1996) published a model consisting of four types primarily targeted towards virtual online worlds: *killer*, *achiever*, *socializer* and *explorer* (see Section 3.3.3). In addition to this basic model, more recent ones include finer grained player types and other game genres (see Section 3.3.4). Thus, when designing a game it should be examined what type of players are most likely to be attracted by it and if these players match the intended target audience of the serious game.

Another aspect to keep in mind is that there are not only different types of players but also different kinds of how players work with the characterizing goal of a serious game. When looking at the educational sector, there is a multitude of different teaching and learning techniques. Some learners like to learn in a group, others prefer to study on their own in the quiet atmosphere of libraries or at home. While a part of the learners value the additional possibilities offered by serious games, another part might be satisfied by just studying a text book. This does not mean that either of these types are worse or better. By increasing the set of learning tools, however, a potentially larger amount of learners can be accessed, and games can provide a way of opening up a certain topic to a new group of learners.

5.3. Defining a Game Scenario

The creation of a serious game most likely starts with the definition of the characterizing goals. For example, a therapist might have the idea to create a new training application for elderly patients for increasing their motivation to exercise. Another scenario could be that an educational publisher decides to create a new learning game for a foreign language to extend his existing learning materials. In principle each game — serious or not — starts with this initial idea. In entertainment games, it normally is the game designer who comes up with the first idea for a new game by defining the core idea of the game. The basic approach, however, is similar: The game designer wants to find a solution to a *problem* (Schell, 2008, p. 60). For entertainment games, the problem does not have to have many *constraints*. Ideally, a game designer can freely come up with an idea for a new game and then define the problem statement for it, for example, "How can you make a game that combines features of a racing game and a tower defense game?". Here the constraint would be that the resulting game should include elements of both game genres. Up to this point the constraints are arbitrary and could be completely changed. With serious games there is at least one predefined constraint, namely the characterizing goal. Looking at the training game, the constraints are that the game should be used in therapy and that it should be tailored towards elderly patients. The resulting problem statement thus might be the following: "How can the training outcome of elderly patients be improved by including game elements into the training process?" Even technical elements can be included here. For example, when it is clear that the game should be used in a specific environment where there is only outdated hardware available, it does not make sense to design a game with high hardware requirements from the beginning. Defining such a question (or multiple ones) is important, because at any time during the designing process it can be checked if the project still follows this initial question.

Together with the characterizing goal, another decision should be made right at the beginning of the design process: the determination of the target audience. Looking at the examples above, it would be elderly patients for the training game. For the learning game there was no primary target audience defined yet. So why not create a game for everyone? As discussed in Section 5.2, there are many different types of players and learners. Creating a game that fits all types is practically impossible, because interests may not only be manifold but even conflicting. The result will not be a game that everyone likes but a game that no one really likes. Instead, it makes sense to clearly decide on the intended target audience. This does not mean that all but one target group should explicitly be excluded from the game. A better idea is to concentrate on common denominators or non-conflicting features (Adams, 2010, p. 74). For example, when designing a game for children and parents, it usually is a bad idea to include violence in the game, because parents will repel this feature. However, if the game allows to either defeat an enemy or to peacefully persuade him both parties can be addressed simultaneously.

Another trap game designers might run into is that the try to make their games just for themselves instead of creating them for the target audience. When male game designers create a game, they might start to include only the features that they like the most, making the game appeal only to males, even though the initial target audience might have included

women as well. Thus, it is a crucial part of the design process to get in touch with the target audience, perform interviews and regularly test the game ideas with representatives of the group. Otherwise a game might be well designed but it will still fail, because it does not address the target audience well.

From the very beginning of the game design process the different parties should work together. Especially game designers and domain experts should cooperate closely when defining the problem statement and the target audience. This is a crucial step towards a successful game. Both parties should agree on common denominators, such as what the exact requirements to the game in terms of the characterizing goal are or how big the game should become (i.e., what budget is available). To answer these questions it helps to perform interviews with experts and in return present and discuss early design drafts. Once the first key aspects are set, the development team should be assembled. Obviously the team will play an important role during the actual development phase, but it can also influence the game design. For example, when there is a visual artist with a specific art style at hand, the game could be designed around it. On the other hand, if the budget is small and there are no dedicated artists available — a situation academic projects often have to face — this fact should be considered as well. As a consequence, the game might only use a simple graphics style or be based on existing materials. Working together with the target audience at this early stage of development also helps in creating successful games by conducting interviews with representatives of the target audience or by looking at common usage patterns.

An aspect of the game scenario can also be the intended play environment. This describes the settings in which a game is played. Different aspects should be considered here:

Supervision Should the game be accompanied by instructors (e.g., in school environments or in therapy) or should it be played alone?

Environment Should the game be played during leisure time or in a controlled environment (therapy, school, …)?

Re-playability Is the game intended to be played just once, or should the game be repeatable (as a training application)?

Time frame How much time is available for playing the game?

Looking at the training game again, the following statement could thus be added: “The game is intended to be played by patients at home for 30 minutes each day over a period of several weeks.” These constraints give a detailed idea of how the setting of the game should look like. If the game was designed to include a story that only lasts for a couple of hours, players would have to play this story again and again and would probably get bored soon. A simple session-based game without an ongoing story where only parameters are getting changed (level setup, difficulty) would be a better alternative.

5.4. Bringing together Serious Content and Gaming

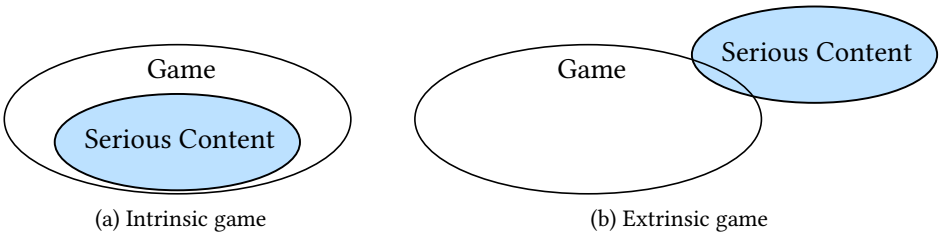
One of the key aspects when creating a serious game — maybe even the most important one — is the integration of the characterizing goal and the game content. Prensky (2007, p. 164) calls this the "art" in the creation process. Without the integration, a game will just be an entertainment game and nothing more. If done wrong, the resulting application will either not be fun to play or will not help to promote the actual goal of the game (Dill, 2013, p. 343). For properly doing it there is not just the one and only way to go. In fact, designers have to decide for every new game which path to follow.

A basic decision is whether characterizing goal and game should be linked statically or dynamically. The former is the more common approach: Serious content and game are geared to each other from beginning to end of the product life cycle. These games can also be called *monolithic games*. A game to acquire a foreign language can act as an example here. If this language is Italian, the game could tell a story about going to Rome and experiencing a series of events where players get to know the Italian language. The game would be accompanied by a matching story, artwork, soundtrack and of course learning content. What, however, if the publisher suddenly decides to create a similar game that teaches Japanese? The whole process would have to start again from the very beginning by creating a new story, different artwork, and so on. The changes do not necessarily have to be that big to run into problems, though. There might also be a situation where a teacher decides to use the learning game in an Italian class, but the learning content does not match her requirements. If it is statically linked, there is no way of changing it.

The alternative to this approach is the dynamic integration of the serious content. The idea here is to provide a game where the serious content can be changed after the game has been created. The game then just consists of a set of predefined building blocks that can be filled with content later. Following the example, the teacher might have to provide a song, a set of pictures and a list of vocabulary items and grammar exercises in the target language out of which the framework then creates a custom game. Game designers have to decide for one option, as further explained in Chapter 6. With statically linked games, they have a higher degree of freedom during the design process, and the game can have a deep integration of serious content and game content. Dynamically linked games, on the other hand, allow for the re-usage of game elements and thus help to increase the potential usage of a particular game.

The decision for a static or dynamic integration should not be misconceived with the integration of the serious content into the actual gameplay. Malone (1980) therefore differentiated between intrinsic and extrinsic learning games (see Fig. 5.2). Intrinsic games provide a tight integration in a way that the gameplay is the characterizing goal itself. A popular example here is a flight simulator game that is used for training pilots. Another intrinsic game would be a multiplayer RPG that is used to train teamwork. In extrinsic games, on the other hand, there is only a loose connection or none at all. If in the flight simulator game players would have to answer a question about biology every 30 seconds to proceed in the game this would be a completely extrinsic game for teaching biology. It also would be not be a good game after all, because the serious content is just used as a "blocker" for the main game parts to proceed, and players might see it as a punishment. A

better alternative could be to use a jump'n'run game that takes place in a specific biological setting (e.g., the human body) where players have to answer corresponding questions to defeat enemies. The serious content and game scenario thus get a connection with this setting, but the actual handling of the serious content is still not the main component of the gameplay. With such an approach, an extrinsic game is a valid alternative to an intrinsic game, if the latter cannot be realized easily. Habgood and Ainsworth (2011) conducted an experiment where they compared two versions of one game in an intrinsic and an extrinsic variant, showing that the intrinsic variant yielded more motivational potential to players. So if possible, intrinsic games should be used whenever applicable.



(a) Intrinsic game (b) Extrinsic game

Figure 5.2.: Different integration strategies for combining serious content and game mechanics.

Ritterfeld and Weber (2006) work on a slightly different level, distinguishing between three types of combining learning and entertainment. Their categorization includes the three elements motivation, reinforcement and blending. The first two categories both base on an additive mix of learning and entertainment. While motivation refers to games that only foster interest in a certain topic, reinforcement works with elements such as highscores or achievements to keep players motivated. Blending, on the other hand, refers to games where learning and entertainment parts are so tightly connected that players cannot distinguish whether they are primarily learning or playing.

As described in Section 5.2, games are mainly played because they are fun. For many players it is just a leisure activity, not connected to studying or being confronted with "serious content". Still, there are entertainment games that can be seen as serious games. *Angry Birds*, for example, teaches basic principles about physics and ballistics. *Dance Dance Revolution* promotes exercising and is actually successfully used as an *exergame* (see Section 4.3.4) (Blumberg et al., 2013). Yet if asked, most players will probably not say that they just played a serious game. Although these games may not have been designed to be a serious game in the first place, they show how well serious content can be "hidden" within a fun game. In educational or learning games this concept is called "stealth learning" (Breuer and Bente, 2010) and is closely connected to the blending paradigm by Ritterfeld and Weber (2006). An early example of such games is *Where in the World Is Carmen Sandiego?* that integrates geographical learning content into a commercial adventure game. It can be used on purpose by designers of serious games. As with the decisions above, there is no right or wrong here, but it mainly depends on the intended usage scenario of the game. If a game is developed to be used in a classroom setting it might not be necessary to

hide the fact that it is a serious game, because all players probably know it before playing it just by understanding the environment. Then again, if a game is supposed to incorporate stealth learning, but the integration is done not subtle enough or designers overshoot, the following can happen: As soon as players start to notice that they are supposed to learn something, they instantly boycott the game, because they wanted to play a fun game, not a serious game. A better way to achieve the desired effect might be just to primarily design the game to be fun to play. If players really enjoy a game they will not mind if some serious content is contained in it. The best indication of this effect is if players notice only after playing the game that they have actually learned something useful out of it. In other situations users actively look for a serious game, for example to use it as a motivational tool. Then it is not negative in any way if a game reveals its nature as a serious game. *Dr. Kawashima's Brain Training* is an example for a specific learning game that is mostly played in leisure time. Ritterfeld and Weber (2006) argue that there are three possibilities how different levels of learning parts in a game influence the enjoyment of players. The *facilitation hypothesis* sees a positive linear dependence (i.e., more learning parts result in more fun) while the *distraction hypothesis* is the direct opposite. Finally, the *moderate enjoyment hypothesis* follows an inverted u-shape that is further described by Abuhamdeh and Csikszentmihalyi (2012). Thus, when deciding which way to follow, it should be clear in what context the game is supposed to be played primarily.

Pure entertainment games are — as the name suggests — created to bring fun to players, to entertain them and to immerse them in the magic circle. The same is true for serious games that are used primarily as motivational tools with the addition of delivering the serious content. However, this does not have to be true for all serious games. As these games usually have a connection to the real world, it can make sense for game designers to deliberately break the isolation of the magic circle. Marsh and Costello (2012) call this *serious experience* in contrast to the purely positive experience of entertainment games. It can be achieved by letting players face unpleasant moments or by giving them topics to critically think about. Examples for such games are *Darfur is Dying* or *Spent*. Both are examples of *newsgames* which call attention to certain social topics (see Section 4.3.2). In case of *Darfur is Dying* it is about the crisis in Darfur in 2008 where a famine endangered people. Not only do these games make players uncomfortable, but they also make it hard to actually win the game. Failing as a intentional outcome of a game can also be used for learning games. Failures can be beneficial if they foster discussions and critical thinking about the respective topics (Charsky, 2010). Abbott (2015) presented a learning game about acquiring academic research skills that also is designed to let players fail. By doing so, players then have a discussion base and learn what to do and what not to do when conducting an actual research project. While this approach is not applicable to all game genres and characterizing goals, it can be a valuable alternative to fun games.

Gameplay in digital games can be coarsely separated into slow-paced games (e.g., a turn-based strategy game) and fast-paced games (e.g., a racing game). This level of pace in a game is an important consideration for serious games. Ideally, the way how the player acts with the serious content should be reflected in the gameplay as well. Prensky (2007, p. 167f) differentiates between action games and reflective games. In action games, players have to react quickly whereas in reflective games players are allowed to think about the

next game move. This should be reflected in the type of serious content. For example, when learning to type on a keyboard, users should train their reflexes without thinking too much. Consequently, the game *The Typing of the Dead* combines this issue with an action game where players have to defeat approaching zombies by correctly typing words as fast as possible. In a setting where more thinking is required, such a game would be highly ineffective because of the built-in conflict: if players think too much they will lose the game, and if they do not think the game will not fulfill its purpose. To avoid such a case, it should be clear which pace the serious content follows. Only in the next step should suitable game elements be created that are in sync with this pace.

5.5. Game Mechanics

In order for a game to become an actual game, it has to include a set of elements and mechanics. The combination of all game mechanics and rules that are internal parts of the game result in the gameplay that the players experience. They define what players can do in the game, how they perceive the game world and what story they experience. This section gives an overview of common game mechanics. However, this should only be seen as entry points for further reading about the different elements.

Each game takes place in a *space*. There can be very different forms of such a game space. In the case of a physical game, it can just be a soccer playground or a chess board. When it comes to digital games, game designers have a high degree of freedom of how to create the game space because they are not bound to physical borders. It can be as simple as a game board for playing *TicTacToe*, or it can be a complex game world with characters and objects in it. Each game space can be represented in different forms. Common techniques are to use a 2D or 3D environment that is rendered to the screen of the player through a virtual camera. Different perspectives are possible here: Top-down, first-person, flying camera, and so on. However, other representations are possible as well: The game *Blindscape* does not use a graphical representation at all but just provides acoustic feedback that is triggered by touching the black display of the player's mobile device. Apart from simple board-like games, the player is normally allowed to move in the game space. This can be done by controlling a virtual avatar or by using a bird's eye view. Some games allow the player to see and explore the whole space while others limit the visibility by employing techniques like the *fog of war* (Adams, 2010, p. 424).

The decision for a characterizing goal and a type of serious content does not necessarily determine the used game space. Figure 5.3 shows two completely different games that share the same basic principle, namely a quiz game. The first game (see Fig. 5.3a) uses a simple 2D space with no option for the player to move in it. In contrast to this, the second game (see Fig. 5.3b) takes place in a virtual 3D world that the players experience through the first-person perspective of an avatar they can move and with which they can perform actions in the world. The decision for one or the other game space could be dependent on the preferences of the target audience (casual or hardcore gamers) or the intended hardware (mobile devices or desktop PCs).

(a) 2D representation with a three-in-a-row game board.

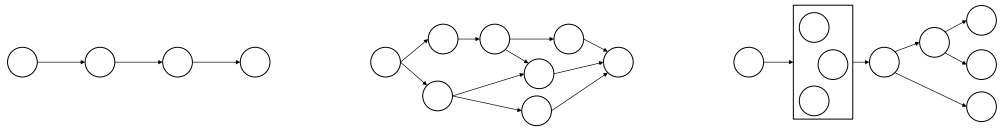
(b) 3D representation in a virtual world with a first-person perspective.

Figure 5.3.: Different representation forms of a quiz game.

If not working with an abstract game principle, there are normally *characters* in a game, as in the example shown in Fig. 5.3b. This includes the player character (or avatar), NPCs controlled by the game, or other human-controlled characters in a multiplayer setup. There are few limitations on how these characters can be modeled. An early and simple example of characters in games can be seen in *Pac-Man*. The game includes one avatar that is controlled by the player (Pac-Man) and four NPCs (the ghosts). Even though the NPCs follow very simple rules, players seemingly observe complex behavioral patterns with them (Millington and Funge, 2009, p. 19). Modern games normally include much more complex character types that can speak, express feelings or perform complicated actions, making them comparable to characters from novels or movies. Players may control one hero or a group of them that gets more powerful during the course of the game. If players do not control an avatar directly, they normally take the role of a director that can influence parts of the game (e.g., giving commands to NPCs, building structures, …).

Both the game world and the characters contained in it contribute to the *story* of the game. The element of story includes two parts: narrative and progression in the game. Narrative uses common storytelling techniques also found in novels or movies. During the game, players can experience an exciting story with several dramatic elements. *Hero's Journey* is a common template for creating an appealing story (Schell, 2008, p. 273). It includes several stages where players experience ups and downs and grow more powerful before they face the final battle. Compared to traditional media such as plays or movies, there is one fundamental difference: games do not have to follow a linear pattern. This is a great opportunity for game designers, because the story can change according to the players' actions. This is where the element of progression comes into play. A game consists of at least one level or scene that players have to complete in order to win the game. Figure 5.4 gives an overview of possible progression types. The traditional way is shown in Fig. 5.4a. Several levels are just connected consecutively, and players have to win all levels to win the game. More complex setups include branches (see Fig. 5.4b) where players can decide which path to follow. When applied to a role-playing game, for example, players could have the possibility to join different factions. As a consequence, players will not be able to see the whole game content during one play-through. While this

increases the re-playability of the game, it also increases the complexity and development effort. Other progression types include level groups and alternative endings (see Fig. 5.4c). In a level group, players have to solve all or a subset of levels in an arbitrary order before the can proceed to the next stage. Alternative endings provide another way to increase the complexity and non-linearity of the story.



(a) Linear (b) Branches (c) Groups and alternative endings

Figure 5.4.: Games can use different forms of progression in the game, reaching from simple linear to complex layouts.

Independent of to what extent characters and story are included in a game, players always perform *actions* in it. According to Schell (2008, p. 136), the actions are based on a set of *rules* that determine what players are allowed to do in certain situations. As a result of an action, *objects* in the game alter their *states* and *attributes*. In a soccer game, an action would be to kick the object "ball", because a rule prohibits throwing the ball. If done so, the ball changes its attribute "position" and enters the state "moving". Actions can be performed either based on *skill* or based on *chance*. The soccer game is mostly influenced by skill. However, factors such as wind can influence the game in an unforeseen way and thus incorporate chance-based actions. Actions and rules are elements that give a game structure and thus are an integral part of game design. By just changing the set of rules, very different games can be created while leaving the other mechanics untouched. For example, with the same deck of cards a multitude of game modes can be created. Or a racing game can either be played like a simulation or as an arcade game, depending on whether the rules allow cars to become damaged or not. Therefore, the core rules of the game should be designed carefully to reflect the original intention of the game, including transporting the characterizing goal in serious games.

There are different interaction forms how players can perform the main actions in the game. If there is just one human player involved in playing the game, the game mode is called *single-player*. Computer-controlled opponents can take the role of other players that human players have to defeat in order to win the game. Examples for this mode are single-player racing games or strategy games. In both cases, players have to compete against an artificial intelligence (AI) opponent that acts as a virtual player to be the first or to conquer the enemy. There are other games, however, that do not require an AI component, like simple card or puzzle games. Here, players just have to work along the rules of the game in order to win. To make playing more interesting and demanding, modes like a time-

trial, where players only have a limited amount of time, can be included in those games. While a time-trial is well suited for fast-paced games, it can impair slow-paced games in a negative way. For the latter type, modes like limiting the amount of wrong tries should be used instead. If the characterizing goal of a serious game is depending on communication amongst the players, a *multiplayer* mode should be used instead. Different modes can be employed if multiple players participate in a game: In a *competitive* setting, players compete against each other, so only one party can win the game, while the others lose. If a *cooperative* mode is used, players have to work together in order to win. This is similar to single-player games, only that there is more than one player who tries to win the game. Another form are *collaborative* games which are slightly different from the previous mode. Cooperative games have one common goal but all players have their own tasks which they contribute to it. Such a game could look as follows: Players have to solve a set of puzzles to win, but solving each puzzle requires only one player. Thus, the game can be won the faster the more players are in the game, but the actions within the game are still small pieces of a single-player game. If, however, an action requires more than one player to perform it, the game becomes *collaborative*. Wendel et al. (2013) used this approach to build a serious game to train team-building skills. Of course combinations of the different interaction forms are possible as well. For example, players might have to collaborate in a team while competing against another team. The decision what mode should be used in a game should again be based on the underlying serious content, so that the interaction modes of serious content and gameplay match.

Every game interacts with its players through an *interface*. It connects the virtual game space to the players' minds. For example, if a player has the thought "my avatar should go from one room to another", the game should provide a way to translate this thought into an actual action in the game. This includes both *input* and *output* components. Common inputs are keyboard, mouse or controllers. More recent techniques include, among others, touch screens, Microsoft's *Kinect*, Nintento's *Wii Remote*, accelerometers found in mobile devices, and virtual reality controllers such as the *Rift* by Oculus VR or the *Steam VR*. The output component is responsible for showing the current game state to the players so that they can react to it. As discussed in the section about game spaces above, this output can take different forms, for example as a 2D or 3D world with different forms of cameras. The physical output normally is a screen. Still, it is important to consider its properties such as size (e.g., desktop monitor, mobile device or TV screen) and rendering capabilities (2D, 3D or virtual reality device). The decision for one or the other input and output technology can be directly influenced by the characterizing goal of the serious game. For example, if it is a training game that involves whole body movements, the Kinect might be the best option. However, the technologies should also be matched with the target audience. When creating a game for users that are unexperienced with PC usage, choosing a first-person controller with mouse and keyboard will result in a very steep learning curve, and an alternative approach that just uses the mouse will work better. Then again, game-experienced users might get frustrated by the missing degree of freedom. Available hardware can also be a limiting factor. For example, when a serious game is intended to be used in school environments that mostly use outdated hardware, this circumstance should be taken into account when designing the game world.

Due to their interactive nature, games should always provide *feedback* to their players (see Section 3.3.2). Whenever players perform actions in a game, there should be some indication about them. This can be as small as highlighting an object after clicking on it or as big as displaying the "game over" screen if the game is lost. This applies to the game parts in the same way as to the learning parts of the game (Erhel and Jamet, 2013). Especially with learning applications it is an important factor that users know what they did right or wrong. A good interface design also includes preparing players for important decisions. For example, if a game includes a story with branches, it is good practice to notify the players before they choose a path from which they cannot return so that they can think about it or just save the game at this point. That does not mean that the whole game should be predictable to the player, though. Game designers can choose to intentionally hide consequences of actions to get a surprise moment later in the game as long as the single actions provide a plausible feedback to the players. This contributes to the factor of immersion that the players experience, that is, the amount of being drawn into the virtual game world.

The level of immersion also depends on the implementation of the user interfaces (UIs), which comprises all menus and elements that are not directly embedded into the game world. Designing those in an intuitive way greatly helps players getting along in the game. Players should know how to interact with objects in the world or just where to find the settings menu to save or quit the game. There is a difference between UI elements that are contained in the game world and those that are not. If players have to open a menu to perform a game action, they will be drawn out of the game world and lose the feeling of immersion. The action of saving a game can act as an example here: The common way to implement it is to build a menu where a player can choose a "SAVE" option and save the game before returning to the actual game. This action breaks the immersion. If the game is an avatar-based game, it can also be implemented without that break: A player could collect gems in the world that can be used at certain locations to "buy" savegames. The same is true for including the serious content into a serious game. It can either just be plugged onto an existing game as a simple menu or included into the game world and its mechanics. When creating an educational game that includes a quiz component, there are different ways how to include it into the game. If the game features a world in which players can move and interact, an easy way would just be to display a UI window that contains a question as soon as the player triggers an according action. The game could pause and continue once the player answered the question. This approach would draw players out of the immersion each time they have to answer a question. A better alternative could be the following: When players have to answer a question, they have to do that in the game world by jumping on a platform that represents the correct answer or by destroying objects that do not contain the correct answer. In this way, game designers can create immersive serious games that create a *seamless* gaming experience for their players.

In an ideal world, game designers would create the perfect game by integrating all of the best game mechanics into one game. Unfortunately, a limited budget often does not allow that. This is especially true for serious games that are developed with a small amount of resources. As a consequence, it can make sense to concentrate on the most

promising game characteristics. The presentation mode of a game is a representative area that allows for a variety of designs, for example when creating a game with a strong connection to the real world such as a training simulation. The game design could look like the following: The player should be able to explore a city in which several points of interest are located. In each of these locations, the player should handle a situation connected to the serious content of the game. With the recent advances in 3D environments and virtual reality it may be desirable to use these technologies for that game, too. Players could then freely explore a realistic virtual environment and feel almost as they were really there. Creating such a complex environment, however, takes up a lot of resources. Furthermore, it bears the danger of falling into the *uncanny valley* (Tinwell, 2015). This theory describes that the more realistic a computer-generated scene/object is, the more skeptical users are in accepting it. Thus, creating a realistic and believable virtual environment is a very complex task that requires a lot of work from both programmers and visual artists. A more practical alternative for the example above could be the following: Instead of a complete virtual environment, players just see a map of the city in which they can click on the different locations. Each location is then modeled by a set of panoramic images in which players can look around and interact with certain objects. The images can be shot at arbitrary locations with very little resources, and the result will probably be better accepted by players than a not fully realistic virtual environment. With such an approach there is more time to optimize the game and to tightly integrate the characterizing goals rather than wasting too much time on partial aspects while leaving other important parts behind.

5.6. Summary

Game designers face a big responsibility. They lead the way for the entire development process of a game from the initial idea to the final game. Therefore, they first should understand what makes a game a game, how it differs from play and how it creates fun. This is especially important when designing serious games, because they are frequently used as motivational tools to promote their characterizing goals. The approaches do not differ much from game design for pure entertainment. First, an initial game scenario is determined based on a set of problem statements. This scenario is then filled with ideas and game elements that are iteratively refined. With serious games, however, a very important part is the integration of the characterizing goals and the inclusion of domain experts. It begins at the definition of the game scenario where characterizing goals and intended usage of the game act as additional constraints. Along these constraints a first game idea is created. Here, inspiration can come from looking at existing applications in both gaming and non-gaming applications for a specific characterizing goal. Game designers also have to decide how to combine serious content and game elements. Both components can be linked statically to create a tight connection between them, or they can be linked dynamically to support interchangeable serious content and to enable the re-usability of the game for different purposes. When designing a game from scratch, a set of game mechanics have to be added to it. This includes basic elements like a game

space, actions and rules. More elements like a story, characters or a multiplayer mode can be added to create more complex games. Interfaces provide functionalities for the players to interact with the game and give them feedback on their actions.

It is important to treat serious games in a holistic approach from the start. The entire design process should also be holistic. Designers should bring together knowledge, props as well as constraints from all involved stakeholders.

6. Game Development Methods

Chapter 5 provided an overview and a guideline for game designers how to come up with ideas for serious games. As soon as this initial design phase is completed, the development of the game can start. This chapter gives an overview of the game development cycle and lists different possibilities how games can be created. Starting from bare game engines, a survey of different forms of authored game creation processes follows. Parts of it were retrieved from the *Games in Education Wiki*[1]. Many of the presented tools are not specifically tailored towards serious games. However, as serious games and entertainment games share most of the mechanics, these tools can be used by creators of serious games, too. In addition to that there exists a set of special-purpose tools for creating serious games. The categorization is intended to give an overview with representative examples rather than listing all available tools/games.

6.1. Development Cycle

Once the initial game design is determined, the development process can start. Nowadays, normally an iterative approach is used for that. So instead of defining all requirements at the beginning, implementing them and then releasing the product, several smaller stages are used in game development. Adams (2010, p. 45) distinguishes between three development phases: concept stage, elaboration stage and tuning stage. The elaboration phase can be repeated multiple times, whereas the other phases are just performed once at the beginning and at the end, respectively. The result of the concept stage should be the initial game design that should not be changed afterwards, because it would have too much impact on all later decisions. For example, the initial design might state that the game should be a racing simulation. If later interviews with the target audience reveal that this genre is not suited for some reason, it would be hard to change it, and the better alternative would be to start a new game from scratch. Then again, smaller details of the game — for example, the track or the color of the cars — can easily be changed later and thus do not have to be specified right at the beginning.

To keep track of all design aspects throughout the entire process, the development team can use design documents. Apart from the function of memorizing ideas and thoughts, they can also foster communication within the team (Schell, 2008, p. 382). Usually there is one main design document that only covers a coarse overview of the whole game (see Section 5.3). This document should be created right at the beginning. In the course of development, more documents can be added, covering topics such as story, game mechanics, artwork or technical requirements.

[1] `http://gamesined.wikispaces.com/Game+Creation+Tools`, accessed 06.07.2015.

With an iterative development process comes the possibility of also including stake holders — domain experts and players — into the process. Ideally, each prototype should be tested. It should be presented to the domain experts as well as to representatives of the target audience in order to get feedback for the next development phase (Christel et al., 2015). Testing can either be done on the whole game or just on certain aspects, for example controlling the game avatar or solving quests in a game. Especially when it comes to UIs, the technique of "hallway testing" can be used, too. In this approach persons who are not involved in the development (e.g., colleagues from different departments) are asked to test certain aspects of the game to get an impression how intuitive these aspects are. When it comes to working with domain experts, different strategies can be used. They can either just be treated as testers and give feedback for the developed prototypes or the final game, respectively. Alternative approaches work closer with domain experts by actively including them into the design process (Druin, 2002; Hourcade, 2007).

At some point in the development process no new features will be added to the game anymore. This can be determined by an approaching release date, end of a funding period or — this is the ideal case — when there are just no more useful features. From that moment on only bug fixing and polishing of the game will be performed until it is finally released.

6.2. Using Game Engines

Various tools are available to game developers for turning the game idea into a playable game. Developing a new game from scratch yields the highest degree of freedom for game developers. With the big publicity digital games face today, many different game engines have been created to help game developers create their games. An engine already comes with a set of basic features such as managing the main game loop and the asset library, providing graphics rendering and sound output, or more advanced techniques such as physics or character animation. It normally also provides an interface to the game logic that can be created in some programming or scripting language. The game content itself is either created manually, for example by creating and importing models to create a game level, or in an automatic manner by using procedural content generation (Hendrikx et al., 2013). By hiding unnecessary low-level mechanics from game developers it thus acts as a kind of authoring tool. However, a complete game engine is very complex and requires a lot of studying and programming work. To also allow non-experienced game developers to create custom-made games, various simplified game engines have been created in the recent past. Representatives of both types will be presented in the following.

6.2.1. Complete Game Engines

A game engine is a software toolkit specifically made for creating digital games (Gregory, 2014). Depending on the engine, game objects and game logic can either be created purely in code, or an editor is provided that allows to manipulate the game objects/assets via a graphical user interface (GUI). Well-known representatives of commercial engines are

Unity, *Unreal Engine* and *CryEngine*[2]. All of them provide similar features like modern 2D/-3D graphics, a visual editor, extensive scripting support and multi-platform support. Open-source alternatives such as the *jMonkeyEngine* are available as well with a comparable feature set. Apart from those there are also specialized game engines. For example, the *AndEngine* is a game engine specifically for the Android platform.

With the features a game engine provides, the development process of digital games is simplified. Developers do not have to cope with low-level graphics programming or basic mechanics such as collision detection. However, a full game engine requires knowledge on programming/scripting, modeling and game design. This makes the game creation process with such tools inaccessible for people that do not have such an expertise.

6.2.2. Simplified Game Engines

In contrast to complete game engines, other frameworks have been created that simplify the creation process. *GameMaker* and *Gamestudio* are examples for such engines. They still allow professional game developers to create any game by providing the same tools as complete engines. In addition to that they also provide assistance to novice developers where only little scripting or none at all is required to create games. *Construct 2* and *GameSalad* are similar engines for creating HTML-5 based games that do not require any scripting. Another approach is to provide specialized game creation tools. For example, the *Sandbox Game Maker* offers an in-game editor for creating game worlds. A scripting component can be used to add logic to the created world. The *Extensible Graphical Game Generator* is an early example for a domain-specific framework for creating simple rule-based games like poker or chess (Orwant, 2000).

All these simplified game engines are geared towards novice game developers that still want full control over the game mechanics, taking in account the application fields of the engine. Developers have the freedom of choosing a game scenario and of including a set of game mechanics (see Section 5.5). Thus, simplified engines are able to make programming obsolete but still require the role of the game designer in the game creation process.

6.2.3. Authored Game Engines

An even more accessible approach to build one's own games is to use authored game engines. They simplify the game creation process even more by providing a predefined game scenario and fitting mechanics. Thus, game developers do not have to create a whole game design but they can just adapt the scenario to fit to a certain story or setting. A variety of tools exist that provide different predefined game mechanics/genres. For example, the *Adventure Game Studio* helps to create traditional point-and-click adventure games whereas *ADRIFT* can be used to create text-based adventures. While being specialized to one genre, it still offers a high degree of freedom by providing support for scripting and the use of own graphics. A similar approach can be seen in *RPG Maker* that can be used to create traditional RPGs. *Ren'Py* is an engine only for creating digital narratives and simple

[2] Descriptions along with references to the web pages of the presented tools in this chapter can be found in the glossary at the end of this thesis beginning on Page 241.

dialogue-based games with a simplified scripting language. In addition, tools that do not require any programming knowledge are available as well. *GameGuru* offers an authoring system for creating FPS games. Simple side scrollers — games that normally feature a 2D game world where players move from left to right followed from a side-camera — can be created with the *Scroller Game Creator* that does not need any scripting or programming either. Furthermore, *Silent Works* offers a set of tools to create FPS games, third-person adventure games, side scroller games and games for the Android platform. *ARIS* acts as a last example for authored game engines. It was made for creating location-based mobile games that — just as the previous tools — do not require any programming knowledge. However, as an open-source platform it allows anyone to modify the platform itself.

6.3. Using Serious Games Authoring Tools

Section 6.2 listed a variety of game creation tools with differing levels of complexity, or freedom for the game designer, respectively. All of these engines — most of them commercial — were not made for serious games in the first place, although they can be very well used to create such games. In contrast to these tools, a multitude of authoring tools have been developed that were specifically made for creating serious games. These tools can be categorized into different levels of complexity as well.

6.3.1. Generic Authoring Tools

Referring to regular game engines, generic authoring tools can be compared to either simplified or authored game engines. The main difference is that authoring tools have been created with the primary domain of serious games in mind. Just as their pure entertainment counterparts, they allow game developers to define their own game logic. No programming/scripting is necessary to create a game, but it might be additionally supported to create more complex scenarios. An overview of available authoring tools will be presented in the following.

StoryTec is a full authoring tool to create games based on point-and-click adventures (Göbel et al., 2008). It features a graphical editor that does not require any programming. Users are able to define scenes, actions and conditions that can be combined to create a whole game. Furthermore, the framework also includes measurement and testing components that can be used by game creators to evaluate the game. A similar approach is followed by the *<e-Adventure3D>* authoring tool (Torrente et al., 2008). It also concentrates on adventure games but works with 3D game worlds. Working with a 3D world has the potential to create more immersive games, but it comes at the cost of having to spend more effort on the creation of the world and the included object models. Erdem et al. (2009) presented an authoring tool for creating scenario-driven 3D games for training. In contrast to the previous tools, their system explicitly requires the work of both visual artists and domain experts — they take the role of trainers in this scenario — to create a game experience for trainees. *SeGAE* is another tool for creating arbitrary games by using a full authoring tool (Yessad et al., 2010). The framework generates games that use the *Adobe Flash* platform and thus produces games that can be played in a web browser.

Another tool that is geared towards use in schools is *MissionMaker*. It lets users create game worlds and logic in a visual editor without the need for programming.

While authoring tools can be used to create learning games, they can be used as learning tools themselves, too. Several projects have been presented that use the game creation process to teach programming. *Alice* is an authoring tool to create story-based narratives or games in a 3D environment (Kelleher and Pausch, 2007). At the same time, game creators learn basic concepts of programming and the Java programming language. A similar approach can be found with *GATELOCK* which also teaches programming skills to children (Yatim and Masuch, 2007). While *Scratch* is a generic framework for creating small games or narratives, it also falls in the category of authoring tools that teach programming. The *Kodu Game Lab* even goes a step further by also teaching creativity and storytelling in addition to programming[3].

6.3.2. Specialized Authoring Tools

Full authoring tools face the same problems as simplified game engines. Both do not require a dedicated programmer or developer but they still depend on the expertise of a game designer in order to create a meaningful and fun game. Nelson and Mateas (2008) have worked on closing the gap between non-professional game designers and simplified game engines by providing a platform/framework that assists game developers in game design decisions. An even more complete approach is to fully relieve game creators from game design considerations. This can be achieved by providing a set of fixed game scenarios that can be filled with a variable serious content. A simple example for such tools is *Hot Potatoes*. It is intended to create web-based learning tools by using elements such as quizzes or crosswords. Other than that, however, it does not include more sophisticated game elements. A more recent tool is *LearningApps.org* which also allows any user to create small learning scenarios based on a set of predefined templates. Specialized to the area of training simulations, van Est et al. (2011) developed a framework that allows instructors to adapt existing simulations on a high-level abstraction. In contrast to the web-based tools mentioned above, this framework features a 3D game world that is better suited to create full games, however it is limited due to the restriction to training simulations. This leaves the area of specialized authoring tools behind when compared to the multitude of tools that are available as full authoring tools or game engines.

6.4. Using Existing Games

When transforming an idea into a game, game designers do not necessarily have to rely on creating a new game from scratch. Instead, they can also look for existing games that can be used as-is or in a slightly adapted manner. These so-called commercial of the shelf (COTS) games are a viable alternative to custom-made games, given that the scenario of the game matches the intended usage scenario. Charsky and Mims (2008) gave an overview of different projects with a focus on classroom usage in schools. One game that

[3] `http://www.kodugamelab.com/about/`, accessed 06.07.2015.

has been used frequently in classrooms to deliver knowledge about history is *Civilization III*. Multiple studies were conducted with the game showing that the game can indeed be used as a learning tool, although is has not been designed as one in the first place (Lee and Probert, 2010; Squire, 2005; Squire and Barab, 2004). *Making History* is a similar game that also has been used as an educational tool in classrooms (Watson et al., 2011). However, the educational sector is not the only one where COTS games are being used. For example, (Fong, 2004) examined the usage of such games for military applications (see Section 4.3.5).

Many games explicitly allow players to adapt the game by creating modifications to the game, so-called *Mods*. *Half-Life* is a popular example for such a game. Because of the well-supported modding support, a whole sandbox game called *Garry's Mod*[4] has been created and is now available as a stand-alone product. Mods can be small such as only changing textures on models, or they can have a big influence on the original game. In case of bigger transformations, changes to the code and integral parts of the game are necessary, making this task unaccessible to novice users.

Games with Authoring Components

Until now, the term authoring tool was used for tools that produce a game that can be played once the creation process is finished. Thus, the processes of creating the game and playing it are strictly separated into two phases. A portion of games break this separation by incorporating authoring mechanisms into the gameplay itself. These games allow players to create parts of the game while playing to use them later in the game or possibly to share them with other players. A popular example in this area is *Minecraft*. An essential game mode is a sandbox mode that allows players to build arbitrary objects out of different kinds of blocks. These objects do not have to be static, on the contrary. For example, several projects have been realized where an entire computer — including processor and main memory — was built within the game which then could be used as an educational tool to learn basic computer operations[5]. There is also a modded version of *Minecraft* called *MinecraftEDU*[6] specially made for educational purposes, for example, to teach programming skills. Another game that bases on the sandbox principle is *Project Spark*. It allows players to build own scenes and stories or whole games within the game itself. This story-based approach comes even closer to being an authoring tool, because players can include their own logic into the user-generated content. The game *The Magic Circle* even addresses the whole game creation process in a humorous manner by letting the player play a seemingly unfinished game that has to be completed and filled with content. This is also reflected in the title that references the concept of the Magic Circle described by Huizinga (1955), while the game lets the player break out of it deliberately.

[4] `http://www.garrysmod.com/`, accessed 31.07.2015.
[5] `http://www.computercraft.info/`, accessed 31.07.2015.
[6] `http://minecraftedu.com/`, accessed 31.07.2015.

6.5. Summary

Game development normally follows an iterative approach where the initial game idea is turned into the final game in several development steps. However, there is not just one way how to implement this technically. As the previous categorization showed, game developers have a whole set of different approaches to choose from. The primary parameters that differentiate them are as follows:

Level of Freedom The amount of freedom a developer has to model ideas with a certain tool.

Ease of Use The amount of technical knowledge (programming, graphics design, game design) that is necessary to use the tool.

Obviously, these two parameters are inherently contrary: the more freedom a tool offers the more knowledge is necessary to operate it and vice versa. A generic game engine such as *Unity* can be very well used to build a serious game, but a specialized tool like *LearningApps.org* cannot be used to build an arbitrary game. Then again, creating a learning element with the latter takes not more than a few minutes, while creating a whole new game from scratch can take days up to months. Figure 6.1 shows a graphical representation of the previously presented tools and games.

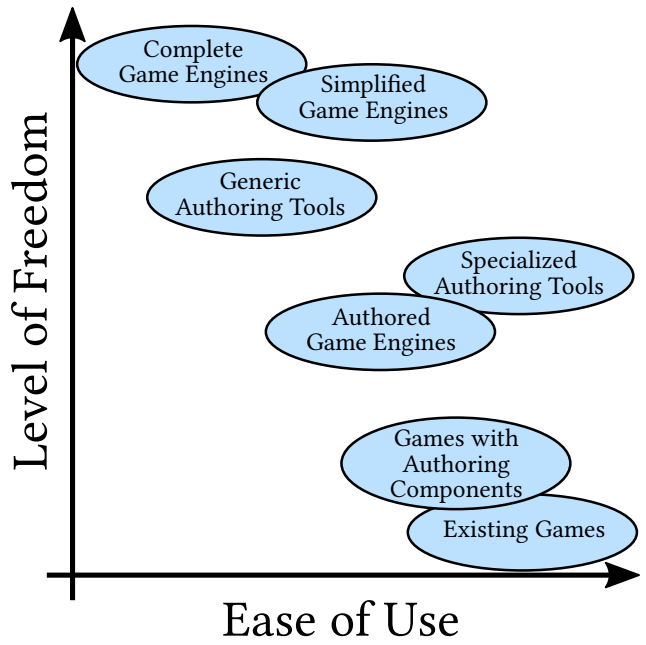


Figure 6.1.: Classification of the different game creation methods.

Another aspect that can be seen in the categorization is that there are no hard borders between the categories when it comes to the separation of entertainment and serious games. Except for a few tools — particularly the specialized authoring tools — there is no

reason why a tool should not be used to either create a pure entertainment or a serious game. This is mainly due to the fact that there is no essential technical difference in creating both types of games. As described in Chapter 5, both game types share the same basic elements. When it comes to reusable games or games with user-generated content, however, there is a chance for serious games frameworks to include mechanics specific to a certain type of serious content. The main goal here should be to create frameworks that do not require any knowledge about game development — including game design and technical development. Such tools could be used by anyone to create custom-made games that incorporate both a fun gameplay and a meaningful connection of game parts and serious content. However, more research is necessary in this area to fully realize this idea. According to Mehm et al. (2012), there are several areas where authoring tools could be extended. This includes assistance in creating game worlds by supporting procedural content generation or the authoring of multiplayer games — an area that has not been covered sufficiently in the past.

As a result of the categorization it can be stated that there is a sufficient amount of generic game development tools, both for entertainment and serious games. Simple-to-use tools for creating serious games, however, are still underrepresented. In addition, the majority of the specialized authoring tools only incorporate small game parts and thus cannot compete with "full" games. This makes it hard for novice game creators — such as teachers — to make games that are both fun and meaningful. As part of this thesis this area will be examined in further detail (see Chapter 9). The main challenge here is to find a combination of game and serious content that is flexible enough to support different topics of serious content while still maintaining an engaging gameplay.

Another aspect that could be improved in future work is the provision of game engines that are specially made for creating serious games. These tools would be different from existing solutions in that they would offer the freedom of full game engines while providing elements that are used by a whole set of serious games. For example, an engine for serious games in the health sector should incorporate an analytics component which supports measurements for various health parameters (e.g., heart rate, blood oxygen levels, stress levels). Such a component would not restrict the type of game or its scenario as is the case with more restrictive authoring tools. Instead, it could be used like any other component of the game engine, like the physics or audio component.

7. Case Study: Mobile Quiz Game

The previous two chapters dealt with various considerations for creating serious games, both for the game design and the implementation phase. An integral aspect of the design phase was that emphasis should not only be put on a good integration of the serious content, but also on an engaging game design. When it comes to the actual implementation phase, however, game creators often face the problem of limited resources/budget. As a consequence, compromises have to be made to keep the development effort low. Using the example of a simple quiz game, this process will be illustrated in the following case study. The results of this study were published in Mildner et al. (2015).

First, different models for the characterization of game elements are analyzed and compared. Then an adapted model is applied to the design of a component-based learning game. Various game elements can be added to the game dynamically. This includes, among others, different forms of presentation, challenge, competition and constraints. Using this application a user study was performed to evaluate which game elements are most effective in delivering knowledge as well as in fostering motivation. Results show that a combination of game elements is suited best for influencing both factors positively.

7.1. Background

Digital learning games have become a common tool to deliver knowledge in a playful manner. One key aspect of them is the strong motivational factor such games have: Ideally, learning games foster the intrinsic motivation of players to learn and to acquire more knowledge. However, while pure entertainment games evolved to a mass market, attracting millions of players each day, learning games are still a niche market. This has several reasons. First, developing a learning game does not only involve the creation of an engaging gameplay. It also depends on a meaningful inclusion of the learning content. This content may be specialized or changed frequently, making the game creation process costly. To overcome this, authoring tools have been developed that allow non-professional game creators such as teachers to create their own games in a convenient way, as described in Chapter 6. However, there is another reason for learning games not being as successful as entertainment games: Due to limited budgets, the majority of games are developed with the primary focus on the integration of the learning content. This often leaves the fun parts of the game behind and thus does not cause so much motivation in players.

When looking at specific game elements, not every element yields the same motivational aspects for all players. So, when creating a learning game, designers have to decide on which elements to put the emphasis, especially when dealing with limited development resources. Should much development effort be put into a visually pleasing graphical

presentation of the game, or should the effort better be put into developing a multiplayer functionality? Is it better to have tight integration of learning and game parts, or will users be fine with having only some small motivational elements on top of a normal learning application? This topic is further examined in this study. After a look at related work, a model for characterizing game elements is presented in Section 7.2. It bases on the characteristics presented by Charsky (2010) and is extended with the yet not considered element of *presentation*. Based on this model, a component-based learning game was developed that is described in detail in Section 7.3. It builds up on a simple quiz to which various game elements are added. Instead of evaluating a game as a whole, this modular game allows to evaluate each game element on its own. By doing so, a study could be conducted to test which game elements have the highest influence on the perceived learning outcome and to the motivation of the players. The evaluation of the conducted user study is presented in Section 7.4.

Apart from the model of game characteristics by Charsky (2010) that is further explained in Section 7.2, similar models were introduced recently, as also described in Section 3.3.2. Hunicke et al. (2004) presented the MDA framework which looks at game characteristics both from a designer and a consumer perspective. Similar work was done by Cowley et al. (2008) who also transfer the flow theory to video games. These models deal with video games in general and thus do not take the learning aspect into account. Mitgutsch and Alvarado (2012) proposed a *Serious Game Design Assessment Framework* to not only look at the content of serious games but also at their design. They work with six categories: purpose, content, fiction/narrative, mechanics, aesthetics/graphics and framing. This categorization is used to evaluate existing games as a whole but not the isolated components. Other models concentrate on the distinction between *play* and *game*. Songer and Miyata argue to move away from using simple game elements often found in gamification approaches and move to a "gameful" experience that fosters an intrinsic motivation of players (Deterding et al., 2011; Songer and Miyata, 2014). They propose a playful affordances model that builds around the elements contest, sensation, exploration and imagination. A similar approach was presented by Lucero et al. (2014) in their *PLEX framework*. It uses *experiences* taken from well-known entertainment games and has the goal to not only use the restricted form of games found in gamification approaches but to use playfulness, that is, non-restricted play which is spontaneous and not as much bound to rules.

Building up on the aforementioned models, several studies in the field of characterizing components in serious games have been conducted. Plass et al. (2013) evaluated an educational mathematics video game where both motivational aspects and learning performance are considered. They used one game with different modes of player interaction, namely individual, competitive and collaborative gameplay. As a result, the competitive mode yields the highest learning performance, while collaborative gameplay helps to increase the long-term motivation of the players. In another study, Lomas et al. (2013) evaluated the connection of challenge to player engagement using the "Inverted-U Hypothesis" presented by Abuhamdeh and Csikszentmihalyi (2012). Evaluating different levels of challenge in an online flash game on mathematics, they could not verify this thesis and instead stated that the easier the game is, the longer players continue to play it. As

with the previous study they also enabled different game elements throughout the study, including time restrictions and a wider range of possible game actions. The elements of perceived challenge and performance are evaluated by Hardy et al. (2014), too. Their study looks at influences of game elements to the perceived difficulty in an exergame. While these studies offer valuable results for specific aspects of game characterizations, still more work should be put into examining characteristics such as different presentation modes of learning games in order to get a deeper understanding how to optimize their effectiveness.

7.2. Game Characteristics

Section 3.3.2 examined different models for categorizing game characteristics. As basis for this study, the model by Charsky (2010) has been used. Compared to the model by Mitgutsch and Alvarado (2012), *mechanics* would be the closest match of topics, but with their model there is no strict categorization of the actual game mechanics.

According to Charsky (2010), the category of "competition and goals" is most important, as almost every game uses both elements. Goals and competition are interrelated, as competition is established when there are rivals, both non-human ("player vs. computer") and human ("player vs. player") as well as "racing against the clock".

Rules are another game characteristic that is used in almost every game. Setting up rules often makes a game unique, as rules give "play" a structure (Prensky, 2007). As related to the aforementioned competition, rules are able to make a game fair for the entire game community, for example when participating in highscore rankings.

The third characteristic is the characteristic of *choice*. It is similar to the term "control" that is used by other researchers, as Malone and Lepper (1987). Choice means to give a player the possibility to choose different options in order to accomplish a goal, so there is no single path that ensures a success but multiple paths.

The characteristic of *challenge* describes a problem that demands the player's ability. The definition of games by Schell (2008), calling a game a *"problem-solving activity approached with a playful attitude"*, identifies challenges as a main element of games. Challenge is closely related to the flow theory as players have to have the right level of challenge to be in the flow channel (Cowley et al., 2008; Csikszentmihalyi, 1991; Sweetser and Wyeth, 2005). *Fantasy* is the last game characteristic that Charsky lists.

Fantasy elements try to motivate players, because they strengthen the aspect of identification with special characters of the game. These elements can also be an essential part that makes the difference of two or more games (e.g., fantasy vs. science-fiction setting). That makes players more involved in the game and also helps to create a playful/gameful experience (Lucero et al., 2014; Songer and Miyata, 2014). Other frameworks such as the MDA framework look at the game experience more closely by distinguishing between social aspects, narrative elements and simple pastime components (Hunicke et al., 2004).

Apart from the presented game characteristics, another one related to the aesthetics/graphics component of the model by Mitgutsch and Alvarado (2012) is used for this study. The aforementioned characteristics are intended to give play a structure, to raise motivation and to generate fun. The first barrier of a game, however, is the *presentation*

(Mildner et al., 2015). If the presentation of a game does not take a player's fancy, he/-she will quickly lose interest in playing the game or will not even start playing it. This theory is also supported by the *Technology Acceptance Model* presented by Davis (1986). He investigates the motivation of the user to use technology, not especially games. As games are a subset of technology, however, the implications are true for games as well. The "perceived ease of use" of a game is directly influenced by several design elements. If these are not satisfying, the player's "perceived usefulness" as well as the "attitude toward using" is lowered. As playing is generally associated with leisure, the usefulness of a game is assessed low by implication. That makes the factor of ease of use even more important. Therefore, providing a game with a clear design which is also intuitive is an essential part of increasing the motivation of a (potential) user. Beside graphics, appearance and usability, presentation also considers the sound of the game and the type of input device a player can control, because they are able to enhance the feeling of immersion which means that a player gets deeply involved in a game.

7.3. Implementation of a Component-Based Serious Game

In order to test different game characteristics, a mobile quiz game called *Quiz+* has been implemented that incorporates various game elements. The game is based on the Android platform to provide players with a well-known usability pattern compared to similar games. The basis is a quiz that consists of one question and four answers of which one is correct. Questions can be entered by instructors in a web-based tool. Users then can download new question sets and store them in a local database for offline usage. Furthermore, a tutorial is implemented that describes the different game modes to new users.

The game is built out of different components that can be enabled or disabled during runtime. By providing different game characteristics which can be set individually, the short-term and long-term motivation of a player are intended to be increased. It also serves as an evaluation platform as all combinations of game elements can be considered individually without having to alter the actual implementation.

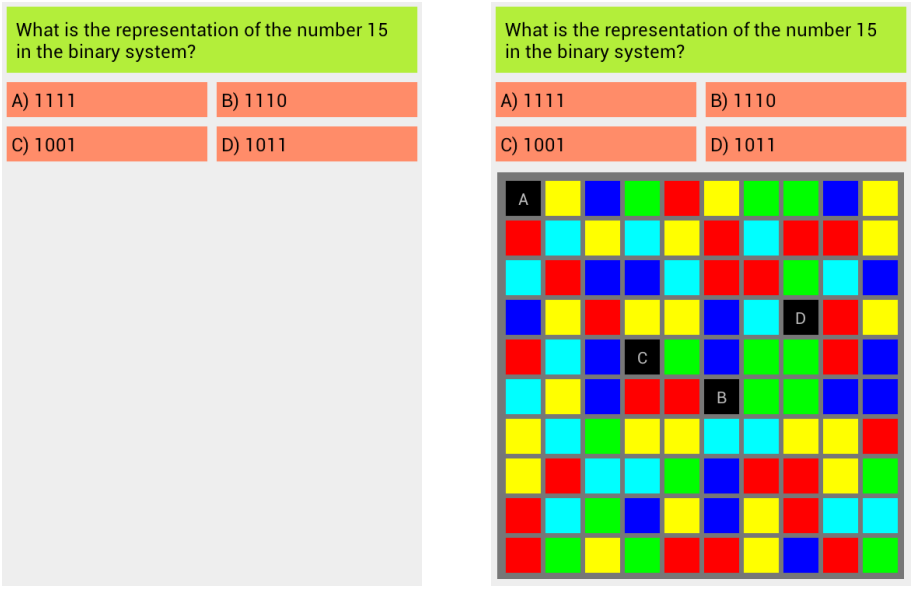
Components

As described in Section 3.3.2 and Section 7.2, there are various characteristics that should be considered in game design. In the following, all components that are built into the game and that can be switched on or off during the game are presented.

Presentation

Since the basic mechanics of a quiz are given, the first element focuses on the presentation of the game. To provide the user with different possibilities to answer a question, there are two presentation modes implemented: *Text* and *Three in a Row*.

In the *Text* mode, the appearance is very straightforward. The player can see the question and four answers in boxes (see Fig. 7.1a). To give an answer, he/she simply has to click on one box.



(a) Text Mode

(b) Three in a Row Mode

Figure 7.1.: Graphical presentation modes of *Quiz+* with an exemplary question.

The *Three in a Row* mode inherits the element of the text mode, so the questions and the four answers are presented at the top of the screen. Furthermore, there is a table of 100 squared boxes forming a board for the Three in a Row game (see Fig. 7.1b). Every square has a color and four of them are labeled with the letters from A to D standing for the respective answer. To give an answer, the player has to bring the square that represents the answer to the bottom. This can be done by swapping a square with one of its neighbors, forming rows of at least three boxes of the same color, making these boxes vanish. If a square representing an answer is at the bottom, the game regards the respective letter of the box as an answer. A wrong answer will make the specific square as well as the wrong answer at the top vanish. If the right answer is at the bottom, the user will see a success message, and the next question will be asked. Every time a new question is asked, the table of squares is shuffled.

The aforementioned mode has parts of several game characteristics that are mentioned in Section 7.2. Giving the right answer to the quiz is a clear *goal* that has to be achieved by following the *rules* of the Three in a Row game. Here the player has the *choice* which boxes to move and how to come up with a solution. Thereby he/she faces two *challenges*: knowing the correct answer and moving the boxes in an optimal way.

Move Constraint

In contrast to the basic gameplay where players cannot lose, a *Move Constraint* component is available for the Three in a Row mode. When enabled, the user has a random number of moves (15–24) to give an answer by bringing the respective square to the bottom. If

he/she fails to do so, the game round is lost, and the next question is displayed. Thus, the player has to think about his or her moves in order to reach the goal without exhausting the limit of moves, resulting in a higher degree of *challenge*.

Joker

The *Joker* component provides players with assistance in solving the game. In the Text mode, two jokers are implemented by simply removing one or two wrong answers by clicking on the respective button. To prevent misuse of this function, it can only be activated on a time-limited basis. There are also two jokers in the Three in a Row mode. However, players have to trigger them by forming special formations with the colored boxes. If four boxes are aligned, the lowest row vanishes instantly. When forming a row of five, a box with a wrong answer is removed. Both forms of jokers increase the *choices* a user can make, and they can prevent the player from getting bored or frustrated if he/she is not aware of the right answer.

Question Selection

A user can choose different algorithms that picks the following question by using the *Question Selection* component. The basic algorithm just selects questions randomly. The advanced algorithm takes the previously given answers of the user into consideration. A prerequisite is that all questions are classified from 0 (easy) to 9 (hard). By saving all answers a player gives, the algorithm then can adapt the difficulty level. For example, if a user manages to answer at least 60% questions correctly in one difficulty level and if he/she answered at least three times, the level is incremented by one. This mechanism falls into the *challenge* characteristic as it helps players to have just the right amount of challenge and thus to get into the flow state (Csikszentmihalyi, 1991).

Highscore

While Plass et al. (2013) explicitly examined multiplayer characteristics, the *Quiz+* game itself has no direct multiplayer functionality. Instead, a ranking system is built into the game so that players can compare their results after matches. There are two highscores, one for the Text mode and one for the Three in a Row mode. Players score points in both lists for answering questions correctly and lose points for not knowing an answer. In the Three in a Row list, players can additionally score points for building rows of boxes. The highscore ranking is presented to a player showing the nickname of the user, the number of questions that were answered, the score and an average ratio of the points per question. Thus, it creates *competition* among players.

7.4. Evaluation

Based on the implemented game prototype, an evaluation was conducted. It was set up in order to answer two research questions:

(a) How well does the implementation of game characteristics in a learning tool help to improve the user's motivation and his or her learning success?

(b) Which game characteristics are especially qualified for the improvement?

The first question investigates whether the integration of game characteristics really is beneficial for the learning outcome. The idea of the game was to add game elements that motivate the player. As the game elements can also distract the user from the learning content, the learning outcome could decrease as well. The second question analyses the different game elements and their individual benefits for the learning outcome. There may be game elements described in Section 7.3 that are very well suited for improving motivation or learning success. In contrast, there can also be components that even worsen the learning outcome.

The implemented quiz game just provides a basic example for a learning game. While there could be more game elements and a deeper integration of the learning content, it still depicts a realistic scenario, as quiz games can be used well to train previously acquired knowledge.

7.4.1. Framework

The evaluation for the serious game *Quiz+* is directly embedded in the game, so the user can click on a button in the main menu and will be directly led to the evaluation mode. It consists of two main parts that are repeated several times: Playing the game under certain conditions and then filling in a questionnaire. First, an easy quiz without any game elements is tested. After that, the *Three in a Row* mode is enabled, followed by four scenarios that alternately include another game element. Finally, a scenario with all components enabled concludes the tests (see Table 7.1). Therefore, it is possible to compare the pure learning tool and the full-fledged game.

Table 7.1.: Scenarios of the Evaluation

#	Presentation	Move Constraint	Question Selection	Joker	Highscore
0	Text	No	Random	No	No
1	**Three in a Row**	No	Random	No	No
2	Three in a Row	**Yes**	Random	No	No
3	Three in a Row	No	**Adjusted**	No	No
4	Three in a Row	No	Random	**Yes**	No
5	Three in a Row	No	Random	No	**Yes**
6	Three in a Row	**Yes**	**Adjusted**	**Yes**	**Yes**

During the evaluation, each user played each scenario consecutively, starting with scenario 0. After three minutes, the game was automatically interrupted, and the user was asked to fill in a questionnaire. The first survey also contained questions about sociodemographic data as well as general data about the user's familiarity with mobile

devices and games. The questions about the scenarios were the same in every scenario, so they are comparable. After the seventh questionnaire, the user finished the evaluation in about 30 minutes.

7.4.2. Results and Discussion

15 people (7 male, 8 female) with ages between 17 and 53 (average 28.4) participated in the evaluation, and every participant tested all seven scenarios, resulting in a data basis of 105 entries. They had to agree or disagree to several statements on a scale of 0 (totally disagree) to 4 (fully agree). The same question catalog was used for all participants. It consisted of a set of general knowledge question categorized in 10 levels of difficulty.

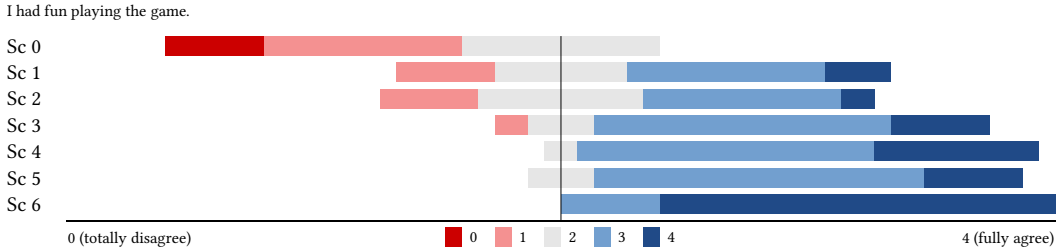
The first part of the results focuses on the achievement of the objective of the game which was to enhance motivation as well as learning success. While the statement "I had fun playing the game" has an average degree of agreement of 1.2 for scenario 0, this degree rises to 3.8 when all game components are enabled in scenario 6. Similar results are achieved for the statement "I would recommend the game". This outcome indicates that fun as well as short-term and long-term motivation are increased by the presence of game characteristics.

The learning success was assessed with different statements in order to have a well-founded result. For the statement "I learned a lot", the degree of agreement rises from 1.7 to 2.7 comparing the scenarios 0 and 6. This increase is not as high as for the fun statements, but it shows that the perceived learning success is better by playing the full-fledged game. As the average number of answered questions are substantially higher in the *Text* mode (23) compared to the *Three in a Row* mode (4), participants may have rated the quality of the learning success over the quantity of the content. However, more in-depth studies may be needed here.

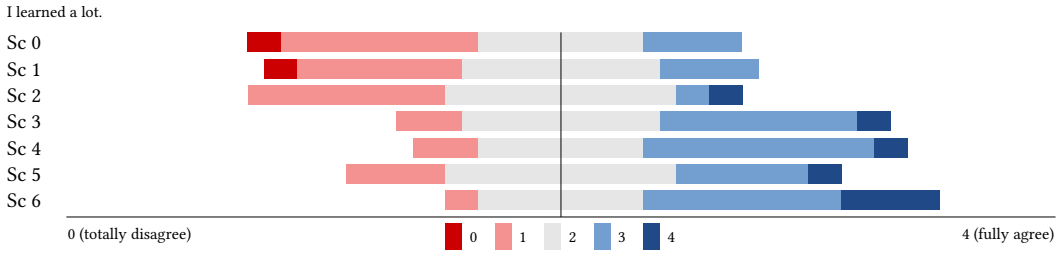
In Fig. 7.2, the distribution of the degrees of agreement can be seen. It shows that the results of the assessment of fun get clearer in scenario 6, so it is not just that the average increases, but the standard deviation falls from 0.8 to 0.4. For the assessment of learning success, a decrease of the standard deviation cannot be observed as it remains on a relatively high value of 0.9. As a consequence, while fun increases for everybody, the learning success does not automatically increase for everybody.

Additionally, a significant correlation of 0.6 between the assessment of fun and learning shows that a game that is motivating through fun automatically increases the perceived learning success. This is an exceptional relationship, since fun and learning are basically seen as two independent variables. On the contrary, the evaluation clearly supports the theory by Dewey (2004) which does not see a general difference in work and play.

In sum, the first research question that investigates the improvement of the motivation and the learning success of the user can be generally affirmed. However, the implementation of game characteristics does help improving both fun and learning. Nevertheless, it is important to be aware of the fact that the learning success was assessed with a questionnaire that only asked for the subjective impressions of the users. Furthermore, the number of questions that are answered in the same time differs significantly depending on the presentation mode.



(a) "I had fun playing the game"



(b) "I learned a lot"

Figure 7.2.: Distribution of degrees of agreement on a scale of 0 (totally disagree) to 4 (fully agree).

The second part of the results focuses on the assessment of the various game characteristics that were implemented. An overview of the results is presented in Fig. 7.3.

For scenario 1 which only implements the *Three in a Row* mode, there is a doubling of the agreement for the statement "I had fun playing the game", from 1.2 to 2.5. This is a high increase, but it can be explained by the various game characteristics this element contains. Similar results are given by the statement "I would play the game again" as well as the statement "The game was boring". This proves the effectiveness for motivation when the presentation is extended. In the assessment of the learning success, there is no improvement from scenario 0 to scenario 1. Thus, this presentation brought an increase in motivation but no achievement for learning.

Scenario 2 which implements the *Three in a Row* mode and a move constraint is slightly lower assessed concerning fun compared to scenario 1. This is due to the more challenging game, so the game is evaluated as more difficult, as also described in the "Inverted-U Hypothesis" (Abuhamdeh and Csikszentmihalyi, 2012). Furthermore, the degree of agreement for playing the game again falls from 2.7 to 2.3. Thus, the move constraint on its own does not have a positive impact for either fun or learning.

The next scenario shows improvements in fun and learning success. While the assessment of fun increases by 16 percent, the perceived learning success increases by 41 percent compared to scenario 1. Since this scenario implements the algorithm for selecting appropriate questions that fit to the user's abilities, the player can be moved to the flow state. This observation verifies Csikszentmihalyi's theory (Csikszentmihalyi, 1991). The effectiveness of the implemented algorithm is proved by the assessment of the difficulty

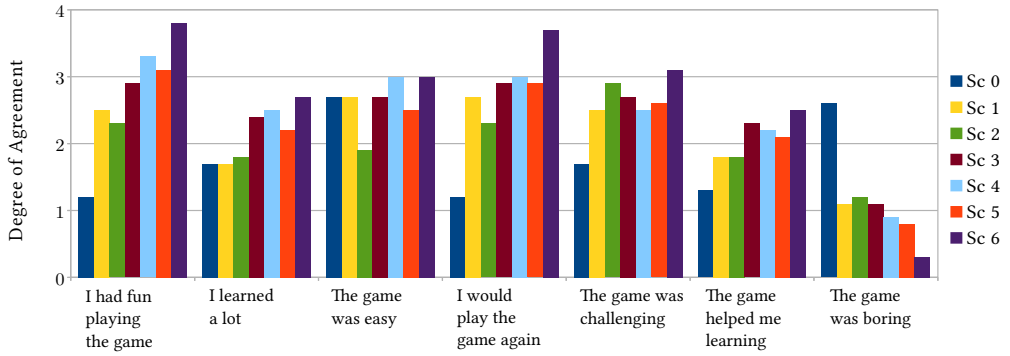


Figure 7.3.: Average degrees of agreement for various statements and the seven scenarios on a scale of 0 (totally disagree) to 4 (fully agree).

of the question, since 87 percent of the users rate the difficulty in scenario 3 as "exactly right". In scenario 6 where the algorithm is enabled, too, everybody rates similarly.

Scenario 4 is similarly successful, as the fun increases by 32 percent and the learning success rises by 47 percent. This game element makes the game easier, since it enables the users to use jokers, so they have a bigger scope to act. In this evaluation, the availability of jokers is the most promising single game element. This may also be due to the fact that the user is able to manage difficult arrangements of the squares that are described in Section 7.3. Thus, the user does not get stuck in problematic situations, preventing him or her from getting frustrated. Surprisingly, this scenario improves the learning significantly. This may be because the user is able to answer more questions.

The highscore ranking which is enabled in scenario 5 is also successful with respect to both fun and learning success, but the improvement is not as big as for scenario 4. The highscore challenges the user and creates competition with others. The user can see his/-her position in the ranking after every answered question, so he or she feels encouraged in trying to go up in the ranking.

The last scenario incorporates all game elements and shows the best results concerning fun and learning success. For example, the ratio for boredom decreases from 2.6 to 0.3 compared to scenario 0 where all game elements are disabled. Furthermore, the standard deviation falls when more game elements are enabled. Additionally, the degree of agreement for the statement "I would play the game again" is very high, so the game offers good expectations in the long run. As this scenario always beats every other scenario, the combination of multiple game elements depicts the best way to transform a learning tool into a serious game that is motivating as well as educational.

7.5. Summary

The presented case study used the concepts from Chapter 5 and Chapter 6 to examine how to create the most effective game in terms of learning outcome and development effort. In order to examine the connection of fun and learning outcome in learning games,

different models for game characteristics were analyzed. Using an adapted model from Charsky (2010), a component-based quiz game that incorporates various game elements was implemented. A user study carefully assessed the achievement of the aforementioned objectives. In general, the game was able to improve motivation as well as learning success significantly. The analysis of every single game characteristic returned different results. While a move constraint which challenges the user more does not have a positive impact on fun and learning success, the implementation of an algorithm that selects the question a user has to answer regarding to his or her abilities leads to an improvement in both fun and learning success. As these two game elements can be linked to the game characteristic of challenge, the theory of flow can be verified. A highscore ranking is able to enhance the examined variables as well. The best result for learning outcome is provided by the implementation of jokers, which simplify the game and enlarge the actions a user can take, while the addition of presentation modes only increases motivation. Although there are elements that are able to improve results more than others, the combination of multiple game elements returned the best result that are intrinsically entertaining as well as valuable learning tools.

This study was carried out on a very small scope with a minimalistic game. On the one hand, this fact proved to be beneficial, because the examined aspects were isolated and allowed a fine-grained view on each of them. On the other hand, it cannot easily be said that the results can be transferred to much more complex games automatically. Wouters et al. (2013) conducted a meta-analysis where they also looked at both the learning outcome and the motivational aspects of serious games. One key finding was that serious games are indeed suited as educational tools because the outcome is better as with traditional methods (i.e., without games). However, they also found that serious games do not increase motivation per se. Wouters et al. argue that this might be due to the fact that games do not increase motivation if they do not create any intrinsic motivation in players. For example, if used as an obligatory tool in classrooms, games will not be perceived as fun by most of the players. Instead, game designer and — if looking at the educational sector — teachers should try to foster situations where learning games can and will be played voluntarily in order to keep the learners motivated. In such situations, games have a motivational benefit and help to increase the learning outcome. The outcomes of this study pose a solid basis for the design of more complex games that will be presented in the following chapters.

Part III.

Studies on Serious Games

8. Games with Static Serious Content

Chapters 5 and 6 dealt with design and development of serious games from a theoretical point of view. While a lot of aspects were addressed, some questions were left open since there is no generally applicable solution for them. To get further insights on the main research question — how game and serious content should be combined to create effective and fun games — a series of games have been developed within the scope of this thesis. This chapter presents games with *static serious content*. With this approach, serious content and game scenario are set at the beginning of the creation phase and not changed later, allowing for a tight integration of both parts. Then again, a high degree of freedom also brings many possible solutions, some better than others. Consequently, practical experiences needed to be gathered. Three games have been developed, all of which originated out of collaborations with external partners. They took the role of the domain expert and gave input to the design process as well. The central question with all these games was how to match the given constraints as well as possible and how to create effective and fun serious games.

8.1. Professor Architecto's Quest

This first project presents an educational game for acquiring knowledge about architecture. In contrast to explicit learning games, *Professor Architecto's Quest* is designed to implicitly foster interest in the general topic and to deliver basic knowledge that can be used in following discussions. The game is geared towards the use in schools with younger students as the primary target group. It has been designed in collaboration with an architect as domain expert. With a tight connection of learning content and game elements, the game acts as an example for statically linked games. The results of this project have been published in (Mildner et al., 2012).

8.1.1. Overview

Within this project, the goal was to bring knowledge about architecture to young students. Architecture itself can be found in many disciplines: from statics and geometry, different building materials, stylistic eras, to the effect of light and shadow or sound in buildings. Through its strong visual aspects, architecture is well suited for the presentation in a computer game. The goal of this game is to provide an understanding of the different aspects of architecture to young students and to increase their interest in this topic. While the game could be played without any further explanation, its primary purpose is to be played as part of a guided course in schools. Instead of only delivering explicit learning

material, however, the game focuses on giving an overview of the many disciplines that are included in architecture.

The game was developed within the scope of a so-called team project at the University of Mannheim. Here, a group of four to eight master students of business informatics works together for one year. Similar projects have shown the effectiveness of such projects (Chaffin and Barnes, 2010; Christel et al., 2015). Not only do the players benefit from the game, but the project participants themselves are able to learn about game development, serious games and team work. This particular team project was created in association with an architect who routinely delivers knowledge about the topic of architecture to students. She already conducted projects with students in primary and middle schools with traditional learning material or non-digital games, respectively[1]. The basic idea of this team project was to transfer her approach to a digital game.

8.1.2. Game Design

At the beginning of the project, a game scenario was determined. It started with the definition of constraints, as discussed in Section 5.3. Those were dependent on the requirements of both the domain expert and the student project. The following list was created:

1. The game should transfer knowledge about architecture to its players.
2. The game should primarily be used in schools as part of courses led by instructors.
3. The game should be modular so that it could be extended easily.

The first two statements were directly given by the requirements of the domain expert. The third statement, on the other hand, was formulated due to the nature of the project. As a set of students was supposed to work on the game, the dependencies of the different work packages should not be too high in case students dropped out or new students entered the project.

Due to the exploratory character of the game, its genre was set to an adventure game. This kind of games allows players to experience a story and require players to look around. Players have to correctly combine hints and items they find in the game world to solve riddles. Each of those brings the players closer to the goal of the game. Such a setting fits into the task of letting players explore and find out aspects on their own. Combined with the third problem statement, the following story was developed:

> *A young student has to write an essay on stylistic eras of architecture for school. Since the student does not know where to start, he/she seeks advice from a professor who happens to live just in the neighborhood. Being an expert in time travel, the professor agrees to help. However, before he can explain anything relevant, a lab accident happens in which the student gets trapped in a time machine on which the professor was working. The student then travels through different time epochs where the time machine lost its energy modules. In order to travel*

[1] `http://www.kunst-raum-bildung.de/Architekturvermittlung/StadtteilDetektive.html`, accessed on 13.10.2015.

> *back to present time, the student has to collect the lost energy modules to fully repair the time machine. On that journey, the young hero gets to know so much about architecture that there is more than enough to tell in school ...*

By setting the main character to the role of a young student, players of the game should be able to identify with the game since the main target group are young students in school as well. Furthermore, the scenario of gathering information about architecture fits the requirement that the game should primarily be played in schools. As such, players can be aware that the game has an educational purpose, and there is no need to employ a stealth learning approach. To account for the modularity of the game, a time travel scenario was included. This allows for the integration of different levels that do not necessarily have to depend on each other as long as the goal of each level has to be to retrieve a working energy module for the time machine. For example, each level could be set in another stylistic area like the Baroque or the Gothic period. The available levels should be — with the exception of the start and end levels — playable in an arbitrary order. This resulted in a level structure that combines a linear layout with a level group (see Fig. 8.1). The term *module* was used for a level or scene of the game that can be played on its own. Consequently, the game consists of a set of modules that are accompanied by fixed start and end modules. With such a design, students who participate in the project are able to create their own complete modules while students who join the project later can easily contribute additional content. At the same time this concept gives players a high level of freedom how they want to experience the game.

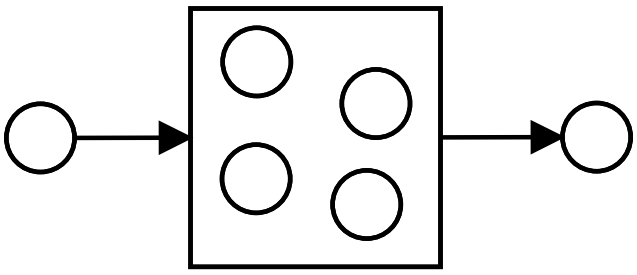


Figure 8.1.: Level layout of *Professor Architecto's Quest.*

The story is well suited for this kind of game. First, the time travel scenario gives broad possibilities on the delivered learning content. Within the scenario it is easily possible to bring new architectural content into the game by creating a new module on the desired epoch or by adding new content to an existing module. Because of the non-linear composition of the modules, the game can be extended without changing key aspects of the story. Second, players have the opportunity to discover various aspects of architecture along with the character of the game. To better support subsequent discussions of the game, a virtual notebook is introduced. As the game proceeds, content is added to this virtual notebook that the character uses to write his/her essay. These notes are generated dynamically by the player's actions and can be used in a subsequent discussion of the game. In this way, each player can tell his/her own story by solving tasks in different ways or in a different order, or by leaving out some tasks or modules completely.

During the design phase of the game, efforts have been made to create a proper flow for the gaming experience (Cowley et al., 2008; Csikszentmihalyi, 1991). The knowledge transfer of the game follows a stealth learning approach. This is in contrast to other educational games where learning and fun phases are strictly separated (Prensky, 2007). In *Professor Architecto's Quest*, there is no such distinction. Although the game is set up so that the player is aware of the fact that architectural knowledge is to be delivered, the knowledge itself is implicitly embedded into the game's story line. As the game is designed to be played as part of a school lesson, this should be an adequate compromise between awareness of the learning intent and fun of the gameplay. Furthermore, by letting players freely decide which level they want to play next, players can choose according to their current skill level. With this design, the game is not intended to be used as primary learning material in school as the learning success cannot be assured through a game only (Squire, 2005). Instead, the game can be used as an accompanying tool for a course on architecture.

A second aspect to ensure that the students stay in the game flow is to dynamically adapt the difficulty of the game to the player's skill level. To integrate such a mechanism into the game, a tutoring system was chosen. While changing the structure of the riddles can be quite complex, an adaptable level of hints is easy to implement. In this way, the player can actively ask for help if he/she is stuck at a certain point, or the game can automatically detect if a player needs help, for example by measuring the time a player needs for solving a task.

8.1.3. Implementation

While the majority of adventure games are made with 2D graphics, it was decided to make *Professor Architecto's Quest* a 3D game. This was mainly done to put more emphasis on the visual aspects of architecture. Combined with a first-person view, players are able to experience buildings and structures more immersively than with simple 2D graphics. For example, the dimensions of a building can be better illustrated if players are allowed to freely walk around it or in it and to look around. Aspects like the play of light and shadow can be better visualized with realistic 3D graphics, too. This meant, however, that the game had to employ realistic and individualized graphics. For this reason, ready-to-use authoring tools could not be used, and the game engine *Unity* was chosen for implementing the game. *Unity* offers sophisticated 3D graphics along with physics systems and supports all major modeling tools for levels and objects. With its ability to run on different platforms, it is well suited for use in schools.

The game uses a combination of mouse and keyboard as input controllers just as most games with a first-person view. The game starts in the laboratory of the professor (see Fig. 8.2). To introduce players to the story, a introductory text is displayed at the beginning. Once the player has found his/her way around the room and started a conversation with the professor, the accident happens that takes the player on the journey through the different modules. Players can then select which module they want to play and can always return to the selection menu. Once they have solved all levels, the final level gets unlocked that

will take the players back to the professor's laboratory where the game ends. In total, four modules were created which will be presented in the following.

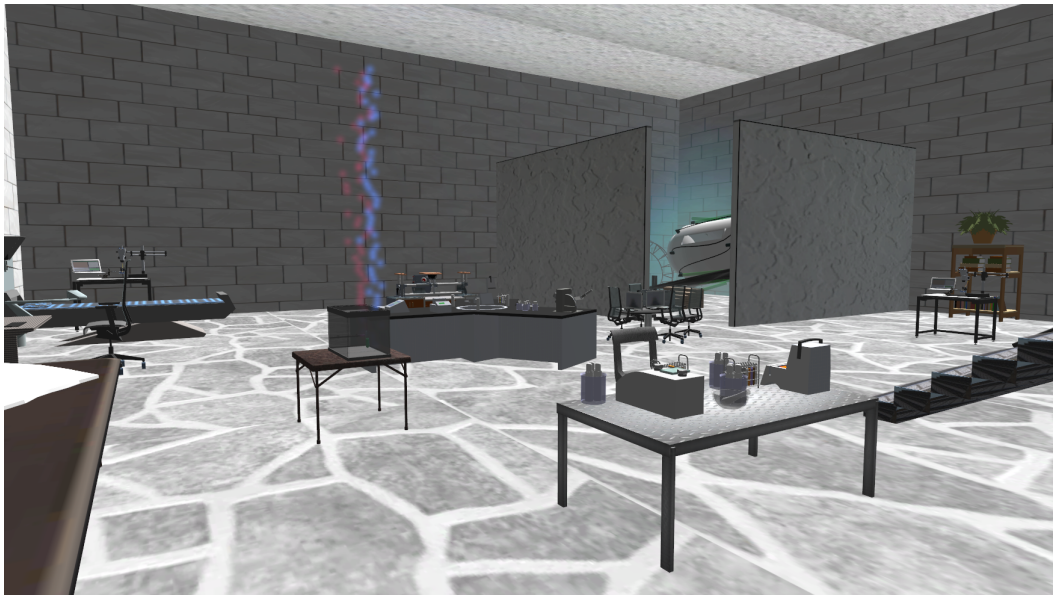


Figure 8.2.: Screenshot of the intro module in *Professor Architecto's Quest* showing the professor's laboratory with the time machine.

Ancient Egypt Module

This level takes the player to ancient Egypt. As an introduction to the scenery, the time machine falls from the sky, crashing into one of the Egyptian pyramids. In front of the pyramid the player recognizes the energy device he/she will be looking for throughout the story of the module. The player finds himself/herself trapped in the room of the pharaoh's sarcophagus. Since the roof has been crushed, rocks are spread in the whole scene, blocking the way out. By pushing them into the correct positions, the path can be unblocked. The exit in the next room is again blocked by rocks, and the player has to find an alternative path. One of the walls in the room is not really robust, and finding and pushing a hidden button causes a huge pendulum to crush it. Behind it, there is a hidden path which the player has to follow. He/she needs to keep the eyes open for irregularities since there are traps on the floor, causing a huge rock to follow the player. At the end of the secret way, the player can finally leave the pyramid.

Arriving outside, the player finds himself/herself standing in front of the huge pyramid in a desert with little vegetation and burning heat (see Fig. 8.3). As mentioned before, the player should remember the energy device; he/she needs to find the place where it was before. After arriving there, the player will recognize that it has disappeared. Footprints lead away from the pyramid to the Sphinx where a camel herder stands who is in possession of the energy device. After a short conversation, he offers to give back the energy

device if the player takes his camels to a well for watering. On the way to the well, the player is confronted with a statics riddle in which he/she has to pass a canyon by using a bridge. The player has to choose the right one from different kinds of bridges; only that one can carry both the player and the camels.

The architectural learning aspects in this module are colors and their combination, sound, proportions, properties of materials, structures and construction, as well as statics. The player needs to use some of the aspects specifically in order to fulfill a task, others are just influencing the situation and the player's subconsciousness. The hieroglyphs and the yellow-white sandstone within the pyramid create an harmonic and warm atmosphere. The hard and structured surface of the stones make the inside of the pyramid uncomfortable and dull, which is completely appropriate for its use as a grave. When moving the character through the inside of the pyramid, the footsteps on the hard stone can be heard, while moving over the sand in the desert causes a calm sound. Additionally, the echo of every sound is very intensive within the pyramid; outside, there is none. In the first room where stones must be moved, a scraping sound is heard, causing the player to realize that there are two hard objects scratching against each other. Within the pyramid, there is complete silence since the walls are extremely thick. Only near the hole in the roof, some cries of birds and calm blowing of the wind can be heard. Outside, those effects are much louder. Since the pyramids and the sphinx are implemented in a similar size to the originals as well as with respect of the distance to each other, the player gets to know the proportions and gets to think about the difficulty to build such landmarks without modern tools.

Island Module

The island level not only takes the player to another time period, but it is set in another universe. At the beginning of the level, the time machine crashes into an extinct volcano on an island that is ruled by a ghost. As a pastime, the ghost is only willing to retrieve the missing energy module if the player proves himself/herself worthy by solving a set of tasks and riddles. The first task the player has to solve is to reach a platform on a mountain (see Fig. 8.4). This can be achieved by building a tower-like structure out of small blocks, similar to games like *Minecraft*. As soon as the player has reached the platform, he/she is able to overlook the area which is necessary to solve the second task: The player has to correctly recognize the shape of a nearby forest. When both tasks are solved successfully, the ghost is pleased by the player's performance and opens the way to the missing energy module which is hidden inside of the volcano.

Several architectural aspects are contained in this module. When building the structure to reach the platform, the player gets to know basic knowledge about the construction process of buildings. This aspect can be further trained on the platform itself where a another building area is located. No goal is given at this point, allowing the player to experiment in a sandbox manner. Furthermore, physics can explicitly turned on or off here. This allows players to acquire knowledge about statics, for example when a construct collapses with enabled physics because of an imbalance. Another learning aspect covers the recognition of shapes in the second main task of this module.

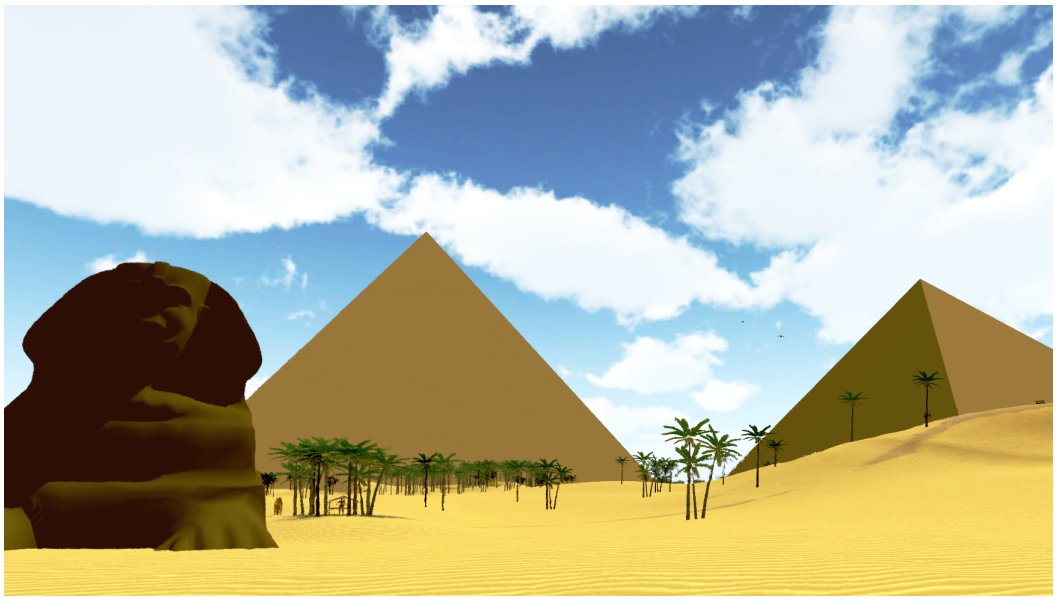


Figure 8.3.: Egypt module *Professor Architecto's Quest* showing the Pyramids in the background.

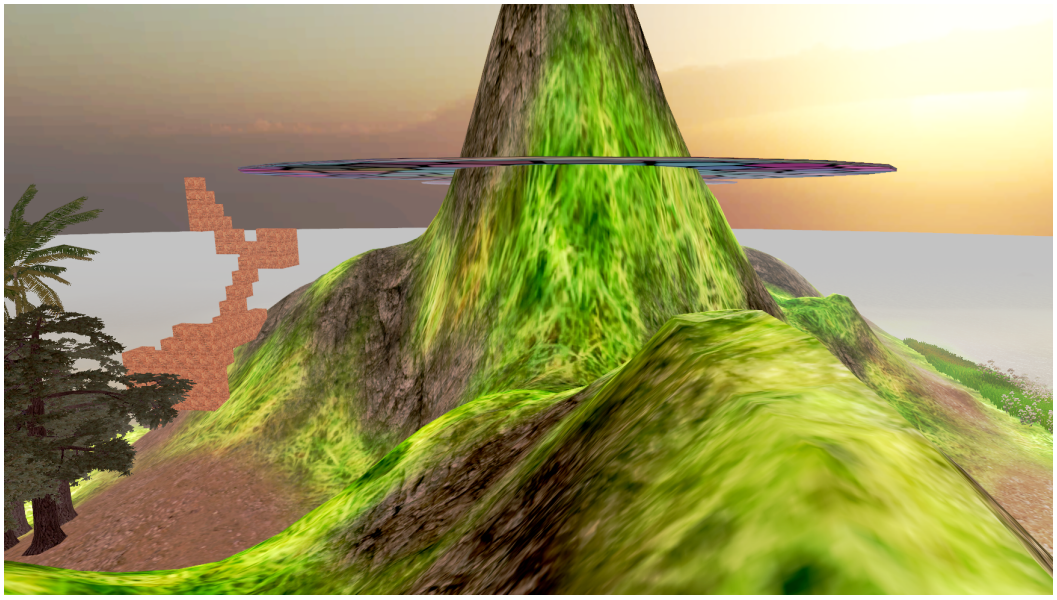


Figure 8.4.: Screenshot of the island module in *Professor Architecto's Quest* showing the island and a structure created by the player in the background.

Medieval Module

The medieval module is set in Europe sometime in the 14th century. In a small hut nearby of the location where the time machine crashed, the player meets a boy who explains that there is a town in the vicinity. He gives the player a map which leads the way to the town and gives some hints how to find the correct path. After locating and entering the town, the player is greeted by the local priest. He tells the player that he found a strange object (i.e., the missing energy module), and that he hid it in the church to keep it safe. The priest is willing to give it to the player in exchange of a favor. The townsfolk want to erect a statue on the market place, but they lack the skill to do so. To achieve this task, the player has to collect some tools: He/she has to get rope from the fisherman at the lake and a ladder hidden in a hut in the forest. After getting the items, the statue can be erected and the priest allows the player to enter the church. The last task the player has to solve here is to locate a hidden switch that will move away the altar under which the energy module is hidden.

Featuring the largest level in the game, important architectural learning aspects are orientation and exploration. Since it is easy to get lost in the forest, the player carefully has to follow the boy's hints and learn how to use the provided map. This task is also beneficial for spatial thinking since the player has to project the map view to the 3D game world. Erecting the statue inherits basic knowledge about physics, for example how to create a leverage that moves the statue. Inside of the church, the player has to pay attention to the play of light and shadow to locate the hidden switch. More learning aspects can be found in the actual architecture of the level: The medieval town features realistic buildings from that time epoch, and player can experience them in an immersive environment.

Futuristic Module

In the futuristic module, the player is stranded in the future. On its chaotic odyssey through time, the time machine has lost a battery in the year 2245. The battery has been picked up by a future historian who is only willing to return it if the player helps him with the following problem: The historian owns a museum for ancient architecture, and a thief has stolen five museum objects. Each museum object is tagged with a tracking device, so the historian has a list of buildings next to which the thief has hidden the stolen objects. The historian asks the player to jump onto a flying platform and look for the objects. In order to provide a better overview of the map of the futuristic city, the perspective will be from above as long as the player is located on the platform. When the player has found the five missing objects, the historian will be very pleased; he asks the player to return each one to its correct socket in his museum. Each socket has a tag, and the player has to decide where he/she puts down which object. Finally, the historian is so delighted that he returns the time machine battery to the player. The player returns to the time machine and continues the game.

The architectural learning outcomes of this scenario are manifold. First of all, the player will get a certain impression of futuristic architecture. Building shapes and materials are not randomly selected but based on the most modern buildings of today. They provide

Figure 8.5.: Screenshot of the medieval module in *Professor Architecto's Quest* showing the town and the church.

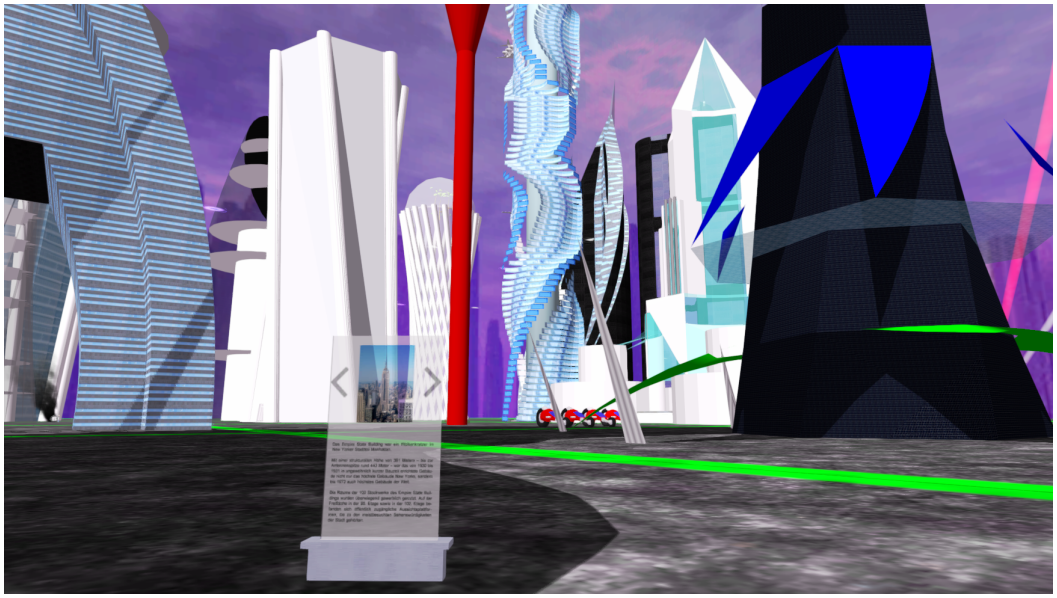


Figure 8.6.: Screenshot of the futuristic module in *Professor Architecto's Quest* showing one of the stolen museum items in the foreground and skyscrapers in the background.

an impression of how future buildings will perhaps look (see Fig. 8.6). Additionally, the player will have to deal with switches of perspective when he/she is flying around on the platform to find the missing objects. The player will receive a picture of a building he/she has to identify according to its shape and appearance. The building might be recognizable from a certain distance, but in order to get there, the player will have to think about a path between the other buildings and — having decided on a path — map it to the view from above. Finally, the player will learn something about architectural epochs when he/she has to put each object on the socket with the corresponding tag.

8.1.4. Evaluation

Since emphasis was put on a meaningful game design, all requirements could be met, both by the domain expert and the nature of the student project. First, the game is geared towards younger students as the primary target group by choosing a matching main character and game contents appropriate for this age group. Second, the game employs a subtle transfer of knowledge with its exploratory gameplay. The impressions players gather during the game deal as ideal starting points for subsequent discussions among players or with instructors. This approach was chosen since the game was intended to be used as complementary learning material. For example, players could talk about how they solved the riddle in the pyramid and what they learned about architecture in ancient Egypt. Third, the modularity of the game has benefits for its use as well as for future enhancements. Since the modules are mostly independent of each other, instructors could students let play only one or two modules if there is limited time or if the other modules do not fit into the curriculum at this point. The game can thus be used just as already existing non-digital variants with the enhanced motivational and visual aspects a computer game offers. A main factor with the motivational factors is the story of the game. In *Professor Architecto's Quest* there are two kinds of stories embedded. On the one hand, there is the main story that will guide players through the whole game and provide a long-term motivation. The story in each module, on the other hand, provides short-term and diversified motivation as each module employs another setting and story. This results in an engaging gameplay that is not only suited as a dedicated learning tool but as an entertaining game on its own.

8.1.5. Discussion

Professor Architecto's Quest is a prototypical example of statically linked games. This means that a high degree of freedom on how to integrate the serious content into the game mechanics was available during the design and development phase. The serious content — namely the architectural aspects — was tightly integrated into the story of the game, resulting in a stealth learning approach. While it is not easily possible to enhance the game without additional programming, the game itself supports additional content without altering the core mechanics and the story. This is due to the modular story of a time travel that was developed during the design phase. It allows to include additional modules (i.e., game levels) without changing the existing ones. The results of this project

show once more how important it is to have a proper game design right from the beginning. For example, if another story had been chosen it would not be that easy to extend the game. Another lesson that could be learned from the project is that even with a limited amount of development resources and time it was possible to create a meaningful game. To conclude, the realization of this game gave important experiences for the following projects that evaluated more aspects of statically linked games.

8.2. Corruptica

In present times of globalization and free market economy, business ethics is an important factor to consider. It helps seeing processes in a holistic view and acting sustainably. However, the topic is still underrepresented in the business world as well as in curricula. For example, more and more scandals in the textile industry are revealed that show the poor working conditions of workers in rundown factories. Raising awareness of ethical aspects contributes to mitigating such questionable methods. Digital games are well suited to do that by providing an environment in which player can experiment and experience difficult situations on their own.

As a way to bring the basic of business ethics to players, the game *Corruptica* was created. The primary target group of the game are students that should be introduced to the topic in a playful manner. The well-known game genre of construction and management simulations (CMSs) was used and enriched with ethical aspects. The game was created in collaboration with a domain expert, a professor for business ethics. As such, the game is similar to the previously developed game *Professor Architecto's Quest* (see Section 8.1). However, it differs in important parts such as the handled topic, the target group and the scope.

8.2.1. Overview

Corruptica was designed in collaboration with an external domain expert, namely Professor Bernwand Gesang from the University of Mannheim. He teaches the topic of business ethics to students and faces the problem that it is often perceived with a black and white thinking: either something is good or something is evil. For example, bribing a local authority to be able to build a factory in some country seems to be wrong. What, however, if the people that would get employment in this factory would otherwise stay unemployed and poor? From that perspective, giving money to corrupt authorities might pose a valuable alternative. A more extreme example is child labor. It is normally seen as wrong, and mostly it actually is. Then again, if an employer offered education within the company to child workers close to adult age where there are no proper public schools available, it again might be an acceptable solution. Such inherent conflicts of business ethics should be transported to a broader public, and a game was chosen for that.

The game should mainly be used as introductory material for students of Professor Gesang's lecture on business ethics. Consequently, the main target group are students. Other groups, such as regular players of related entertainment games, should not be explicitly excluded, though. A good way to achieve this is to create a game that is closely

related to common entertainment games. If games are primarily fun, players will enjoy them, whether they actually want to learn something or just want to play. Several studies have shown the positive effects of such games. For example, Squire (2005) already showed that commercial of the shelf games can be used in classrooms to deliver knowledge to students. In such games, the learning content is tightly integrated into the game and sometimes even hidden from the players.

Several games could be identified that share common aspects with *Corruptica*. When looking at pure entertainment games, the series *Tropico* is closely related. The games are construction and management simulations (CMSs) with the goal to build up a socialistic society somewhere on a tropical island. Players take the role of a dictator. They have to build a city and create manufacturing chains for various goods. Aspects like corruption or exploitation of the own people are integrated into the game as well. However, these are just regular game mechanics, and there is no questioning of such methods.

Looking at the serious purpose of related games — namely business ethics — *Sweatshop* is a good example. The game incorporates aspects of business ethics by critically looking at bad practices in the textile industry. As such, it is a representative of newsgames (see Section 4.3.2). It takes place in factories where goods such as shoes, shirts or hats are produced under questionable working conditions, including child labor. The basic game mode is a modified tower defense game where players have to finish products before they reach the end of a conveyor belt. Workers can be placed in line that all have different traits, except for child workers. The game employs an ethical rating that decreases if players hire children or do not take care of their employees. There are different factories that each includes a series of game levels. The storyline is linear, like in many casual games, so players cannot do anything to change the outcome of the game. There also is no nuanced reflection of the serious content. For example, the manager of the company is always the villain of the game even though in the real world he might be influenced by other external factors, too. To emphasize an explicit learning character, the game shows facts about real working conditions after each stage.

8.2.2. Game Design

For the realization of *Corruptica*, well-known game design principles were employed (see Chapter 5). It started with a collection of constraints which were mainly given by the domain expert. First, the main goal of the game should be to show the inner conflicts of business ethics and encourage players to critically think about such topics instead of teaching explicit learning content that could directly be used in preparation for an exam. Second, the game should be targeted towards students who play it as introduction to the topic in the course of a lecture. As such, the game should be designed for a gameplay time of roughly 60 to 90 minutes. Furthermore, it could be assumed that the game is mainly played once but not repeatedly as it would be the case with training applications, for example.

The main genre of the game was set to a CMS. The majority of the target group studies business administration, and from that it was concluded that this genre would be the most relevant and attractive. A CMS alone would not necessarily deliver any knowledge about

ethical aspects, like shown with the game *Tropico*. Consequently, those had to be added to the regular game mechanics. Looking at the purpose of the resulting serious game, the closest match would be newsgames while the audience for it is mainly the educational sector.

An important goal for the game was to show that business ethics cannot not always be clearly separated into good and evil. On the contrary, many aspects are driven by an inner conflict to choose the smaller evil. To reflect this in the game, a system of different stakeholders was developed. Each stakeholder has different interests that explicitly conflict with interests of other parties. As a result, players are forced to take decisions that cannot be optimal. The following concept for the game was finally developed:

> *On a small tropical island somwehere far away, a big textile company opens up a new branch. The newly hired manager (i.e., the player) is given the task by his/her supervisor to lead this branch to success over ten years. As soon as the first small factory opens its gates, the local residents are more than happy to finally have a opportunity to earn money. With a growing business, however, more and more demands have to be satisfied: Workers long for better working conditions, environmentalists threaten to lead campaigns against the company if it does not act sustainably, customers want both cheap and fair products, and the supervising manager wants to see larger profits to satisfy the company's shareholders. The manager will have to find out if all these interests can be satisfied and how an initially small branch can be developed to a big player in the competitive textile industry without unethical conduct.*

The decision for a tropical island setting had two reasons. The first one was that the game should not be set in a concrete country but in an abstract place that could be in many parts of the world where the handled topics are actual problems. The second reason was a practical one: Water is in ideal boundary for game levels because it both reduces the modeling effort (i.e., the size of the world) and gives players a defined space where they can interact.

For representing the different interests, five stakeholders were designed:

Manager As the one who hired the player, the manager is only interested in profits. He is driven by the profit of his company and tries to reach this goal without a qualm.

Customers This group is driven by an inner conflict on its own: Customers want new and cheap products, but at the same time they value good working conditions and sustainability. Consequently, it is a balancing act to satisfy this important group.

Workers While workers are initially happy to just have a job, they develop more sophisticated needs as the business grows. These include higher salaries and better working conditions and ultimately a worker union — if the player allows it.

Residents Not only workers benefit from the new company but also the residents of the island since the overall living standard slowly rises. However, having factories in the vicinity that pollute the air and the environment will not be tolerated by the residents for long.

Environmentalists Saving the environment is the driving factor for the faction of the environmentalists. With the power to run campaigns that will significantly lower the sales count, they demand adherence to sustainable products and their production.

During the course of the game, players will get confronted with the often contradicting interests of these five stakeholders and have to decide which to fulfill and which to reject. Each stakeholder is represented by a stereotypical character (see Fig. 8.7). Apart from that, most of the game mechanics are derived from well-known CMSs: Players have to construct buildings, hire workers, manage production chains, set prices for salaries and products, research new technologies and deal with occurring quests and events. The game ends after a fixed time frame of ten years of simulated game time to stay within the boundaries of one lecture.

Figure 8.7.: Overview of the stakeholders in *Corruptica* from left to right: manager, customer, worker, resident, and environmentalist.

8.2.3. Implementation

To give players a well-known look and feel of the game, it was decided to use 3D graphics since most modern CMS games do so as well. The game engine *Unity* had already proven to be a useful tool during the implementation of *Professor Architecto's Quest* and thus was selected as the underlying game engine again. In addition to that, modeling tools such as *Blender* and graphics editing software were used to create models, textures and other game resources. The initial version was again developed in a team project, a course in the business informatics master degree at the University of Mannheim. Seven students were working on the game for one year until a first release was completed.

Corruptica employs many characteristics that can be found in related entertainment games. Featuring 3D graphics, it uses a top-down view like in most real-time strategy or CMS games. Functions that do not have to do with objects in the game world can be accessed over menus. Additionally, the game screen offers status information to the player such as the amount of hired workers or the current game time. Figure 8.8 shows a screenshot of the game with a menu in the foreground and the game world in the background. The specific mechanics of the game will be presented in the following.

Both real-time and turn-based actions are built into the game. Game time runs continuously, and players can perform actions anytime, such as constructing buildings or

Figure 8.8.: Screenshot of *Corruptica* showing the main game screen with a burning factory on the premise — an action with many negative consequences for the gameplay and the ethics score.

adapting salaries and prices of sold products. The actual business simulation, however, is only performed once each simulated month. Financial aspects are displayed in a standard balance sheet where players can see revenues and expenses for static and dynamic items (e.g., buildings, salaries, sales) for the last month and year. In addition to the regular mode, events are triggered by actions players perform (e.g., hiring child workers) or on a time basis (e.g., at the beginning of the third year). Players also have the possibility to accomplish quests for certain stakeholders. If accepted, players will get benefits if they successfully fulfill it. Quests can also be declined with little or no consequences, for example when players find them not lucrative at that point in time.

The game starts with a tutorial where the manager introduces the important aspects of the game to players and starts the quest that will accompany players through the game. At the beginning of the game, players have the primary quest to build up the company branch from scratch. They have to construct buildings on a defined building area (the premise) and hire workers. Once they have constructed a headquarters building and a first factory and hired workers for both buildings, production starts, and players can sell t-shirts. A third important type of building is a research center. It gives players access to the research tree where they can unlock improved building types (e.g., level 2 or 3 factories), a new product (shoes) and generic upgrades (e.g., faster production for t-shirts or shoes).

While there is only one choice for hiring administrative workers and scientists, players have the freedom to employ three different kind of factory workers throughout the game, including the option to hire child workers. Salaries for all types of employees can be adapted separately to give the players more freedom on the financial aspects. Since the first premise only accommodates a limited amount of buildings, players will have to buy other premises when they advance in the game. Each of the available premises to buy has different traits like costs and capacity. Additionally, each one is also linked to the interests of a stakeholder group that will be offended if it is bought. For example, the manager does not approve purchasing the premise right next to the first one because it is expensive. The environmentalist, on the other hand, will complain if the cheaper premise in a natural reserve is purchased. Players thus are forced to choose which stakeholder to upset since there is no optimal solution. However, if reputations of stakeholders have fallen and players want to increase them again, they can start campaigns after unlocking them in the research tree. These campaigns are a way to invest money into a better reputation towards a certain stakeholder (e.g., a TV campaign for reaching more customers). Players can also choose to fulfill quests for a certain stakeholder to increase the respective popularity value. Like in the real world, however, not all quests pose good investments.

Different score values and game variables are maintained by the game. Some are visible to players all the time while others are not. Variables thus can be separated into external and internal values. External ones include the popularity value of the players' branch, the current demand and sympathies of all stakeholders towards players. Other variables like the balance and the game time are obviously external, too. Internal values mainly comprise the highscore and the ethics rating. Other internal values such as the demand for the upcoming month — which is modeled to not behave completely deterministic — can be turned into an external value in the course of the game if players research the corresponding technology. This intentional hiding of information was built into the game not to influence players in their decisions. As such, players should not see from the beginning which ethical consequence a certain action could have. On the contrary, players should learn that by seeing the reactions of the different stakeholders to their actions. Another aspect is that external and internal values do not have to correspond all the time. For example, actions like hiring child workers result in a negative ethics rating. However, players will only see a reaction if there is an event triggered that results in a message from a stakeholder. Only then will the respective popularity value be decreased. These events only have a certain probability to reflect the real world behavior where not all scandals get known to the public. Then again, earlier negative actions can be revoked by later decisions such as training child workers to become educated workers. The final highscore and ethics rating will only be displayed to players at the end of the game with a corresponding message from the stakeholders. The game ends either if the player keep the company running for ten simulated years or if the player has to declare bankruptcy, which corresponds to winning or losing the game. Since the final ratings will be displayed anyway, however, it is not important if players actually win or loose the game. Ideally, both endings result in a learning effect that will foster subsequent discussions and make players think about their actions.

Iterations and Improvements

The development of *Corruptica* followed an iterative approach as suggested in Section 6.1. A technical prototype was finished after six month and a first fully working game prototype was completed after one year of development. Consequently, the main concept was set at the beginning and not altered later. During development and with the first prototypes, only small details and mechanics were identified during play testing sessions that had to improved. For example, the decision for a mainly round-based game resulted in periods where players did not have anything to do because they were done with their actions for the current month and had to wait for the next one to begin. A first improvement was to include a decay function into buildings. As a result, players have the additional task to check which buildings should be repaired to avoid them burning down — with obvious negative impacts. Not only did this micro-management task help to keep players busy, but it also had the positive side effect to balance the game economy better since players have to spend money to repair buildings. The second effective mechanism was to include a function that lets players simply forward the game to the beginning of the next month. This function proved to be very effective as players were now able to adapt the game speed to their likings.

Even after the first real prototype, development continued with bug fixing and adding smaller function to improve the usability of the game. This included simple items such as displaying hover texts over GUI elements or showing the revenues of the past month on the main screen for a better overview. Game elements like a "repair all" function and having buildings smoke before they burn down additionally improved the player feedback. The final release was also altered to only depend on interaction with the left mouse button to get better usability with laptops and Apple devices. As soon as the game was deemed stable, it was made available for public download[2].

8.2.4. Evaluation

After its release, *Corruptica* was evaluated by performing a play session in a lecture on business ethics held by Professor Gesang. Before this event, the game was slightly altered by integrating an evaluation module into it which adds an analysis component. It records important variables of the game — including highscore, ethics rating and stakeholder popularities — and transfers them to a central database when the game is finished. The results are recorded and made available in an online highscore and statistics page. Players can choose to assign an alias to their results so that they know which entries in the highscore list belong to them.

The play session was carried out in the last lecture of a term as a voluntary activity. Students were asked to bring their laptops to the lecture and were instructed to download the game in the lecture. Other than that, there was no specific task or instruction given. Players could just play the game at their own will for about 30 minutes before the lecture ended. About 30 students participated in the experiment (see Fig. 8.9).

[2] `http://www.knowledge-gaming.de/games/corruptica/`, accessed 26.10.2015.

Figure 8.9.: Impressions of a *Corruptica* game session played by students in a lecture on business ethics.

After playing, students were asked to fill out a questionnaire. Table 8.1 shows an excerpt of the questions that will be further evaluated in the following. The complete questionnaire can be found in Appendix A.1. 19 participants (12 female, 7 male) answered the survey. The lower number of participants in comparison to the play session can be explained with the fact that the whole activity was done on a voluntary basis, and students were not required to do both parts. The majority of the participants that filled out the questionnaire (17) were students from the bachelor degree in business administration. The evaluation and questionnaire was done to evaluate two main aspects:

- How do players perceive the game? This should include novice players as well as players that are used to play commercial entertainment games.
- How do players perceive the integration of the serious content — namely business ethics — into a business simulation game?

The first aspect was mainly covered by questions A6:1–A6:4 and D1. Questions C1:1–C1:6 then examined the second aspect. Figure 8.10 shows the results of the most relevant questions.

The first research questions can generally be answered positively. Regarding the perceived fun, players mostly agreed with a high mean value of 3.95 in question A6:1. Players also showed a high interest in the topics that the game deals with (questions A6:3 and D1) with a mean value of 3.84 and 3.68, respectively. Although 16 participants stated that they play computer games never or up to once a month, the usability of the game was perceived mostly positively (question A6:2, mean value 3.79) which indicates that the game can be used intuitively. The game also seemed to be balanced well because only five percent perceived the game as “very easy” and the rest stated either “easy”, “exactly right” or “hard”. This indicates that many players were in the Flow channel (see Section 3.3.1) and only some were either slightly unchallenged or overwhelmed. The good results are also reflected in question A6:4 which condenses the aspects above into whether players would recommend the game to others.

Table 8.1.: Selected survey question from the evaluation of *Corruptica*. Identifiers relate to the questionnaire (see Appendix A.1). The questions have been translated since the original questionnaire was in German.

#	Question
A6:1	I had fun playing the game.
A6:2	The game was easy to use.
A6:3	I am interested in the topics that the game deals with.
A6:4	I would recommend the game.
D1	I am interested in the topic of business ethics.
C1:1	The game increased my interest in the topic of business ethics.
C1:2	The game changed my perspective on the topic of business ethics.
C1:3	I was able to extend my knowledge about business ethics by playing the game.
C1:4	The main focus in the game was on the business simulation component.
C1:5	The main focus in the game was on the business ethics component.
C1:6	The game is relevant for my education.

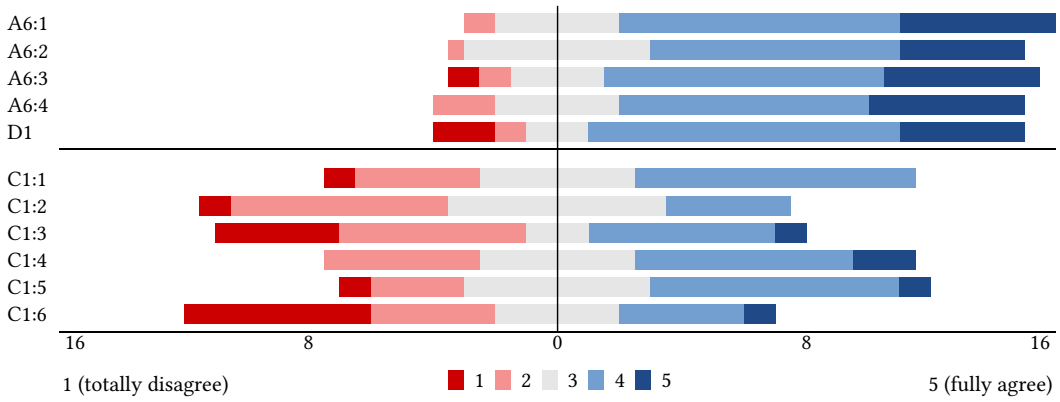


Figure 8.10.: Overview of the evaluation results from *Corruptica*. Question texts can be retrieved from Table 8.1. The bars show the distributions of the five point Likert scales.

The answers about the integration of the serious content into the game — in this case business ethics — were not as clear as the first ones. While there is a slight tendency towards an increase in interest for the topic by playing the game as seen in question C1:1 with a mean value of 3.16, a slight majority of the participants found that the game did not change their perspective or extend their knowledge. This is understandable, given that most players had attended the respective lecture for an entire term. Consequently, they learned all the different aspects from Professor Gesang already, and thus these players were not representative for the actual target group of the game, that is, newcomers to the topic of business ethics. This is even more noticeable in question C1:6 that asked for the relevance of the game for the education of the players. Given these circumstances, the fact that 32 percent of the participants stated that they still extended their knowledge can be seen as a positive result. Regarding the integration of serious content and game mechanics, there is almost a draw between questions C1:4 and C1:5 which asked whether the business ethics components or the business simulation itself is the main focus of the game. Since the answers do not differ substantially, it can be concluded that the integration worked well.

8.2.5. Discussion

The development of *Corruptica* was a comparatively large project. It took one and a half years to produce a playable version, and the resulting code base consists of about 25,000 lines of code. And yet the game is not completely done. For example, in the evaluation session three participants stated that they experienced bugs/crashes during the game (see questions B1–B6 in Appendix A.1). Another issue that came up during extensive play testing as well as in the questionnaire was that the game balance in the second half of the game tends to be too easy if players make the correct decisions right from the start. Consequently, more work would be necessary to make the game accessible to a larger audience.

Letting alone the minor open issues with the game, the results of the conducted evaluation show that the game concept of *Corruptica* works and that a game-based approach can be used to teach aspects of business ethics in a playful manner. The results are even more promising when taking into account that most of the participants in the evaluation were no stereotypical players: The majority was female and did not play much or not at all. However, players still enjoyed playing the game and had no major problems in using the game. This is also reflected in the fact that playing did not stop after the conducted evaluation. Since the game is available for public download, students could play the game in their leisure time, too. Within one month after the evaluation session, 125 game sessions were recorded in total. This shows that the game is interesting on its own.

Concerning the learning outcome of the game, the results of the evaluation are generally positive. In the free answer section of the questionnaire, a couple of students stated that they actually could empathize with the different stakeholders and the difficult decisions they have to face in the real world. However, many students stated that the game is not relevant for their education. This is understandable when taking into account that the students already attended the according lecture. After all, the game was not designed to

directly prepare for the next exam. It should instead make players think about issues and conflicts and this is what has been achieved. Some players even played the game multiple times just to beat the highscore which is an indicator that the game provides motivational potential on its own. Another interesting fact is that the average ethics score was negative after the recorded play sessions which might be an indicator that the game should actually be played more often.

8.3. A Training Game for Alcohol-Addicted Patients

The health sector is a big application field for serious games, as already described in Section 4.3.4. One of the reasons for using serious games in comparison to non-gaming based applications is that games are able to turn a regular task into something fun. This is an especially important factor in training applications that should be used on a regular basis. While an external motivation is usually given when the training is done under the supervision of a therapist, it becomes all the more effective when patients want to do it in a self-motivated manner. Another reason for using serious games and especially digital games in therapy is that games are able to provide realistic and believable virtual worlds into which the players can immerse. This aspect is helpful when a training involves coping with situations the patients usually experience in the real world since a virtual world can provide a compressed and isolated environment for the specific training purpose. The Zentralinstitut für Seelische Gesundheit (Central Instititute for Mental Health) Mannheim (ZI) faces such problems in their therapies. For this reason a joint project was initiated to create a game for the therapy of alcohol-addicted patients. It includes work done by Ueberle (2015) and Timpelan (2015). The basic idea is that players should reenact situations to which they are used in the real world and that involve confrontation with alcohol. The goal of the game is that players actively choose a non-alcoholic alternative over an alcoholic one. By doing this repeatedly, players should train to behave correctly when faced with such situations in the real world.

8.3.1. Overview

Alcohol is normally consumed for hedonistic reasons, that is, drinkers enjoy it or consume it at certain occasions like a party. With alcohol addicts, however, the drinking habit loses its enjoyment and finally becomes compulsive (Vollstädt-Klein et al., 2011). A problem that goes with this behavior is that addicts unconsciously train to show a positive reaction to alcohol related matters. This does not have to be an alcoholic drink alone, but the mere sight of a bar might trigger it as well. Since this is an impulsive reaction, addicts often follow it without actively thinking about it, for example walking into a bar and ordering a drink before consciously noticing what just happened.

A way to make addicts aware of this issue and to train them to actively suppress this impulse is handled by cue-exposure based extinction training (CET), as examined by Vollstädt-Klein et al. (2011) who use this method at the ZI. When addicts actively choose non-alcoholic options, they will train their subconsciousness to follow these impulses instead of the old patterns. This then helps to overcome the addiction. Wiers et al. (2011)

showed this in an experiment where patients had to control a joystick, pulling or pushing images. Patients were instructed to pull non-alcoholic objects to them and to push alcoholic ones away from them. Vollstädt-Klein et al. (2010) conducted similar experiments with images alone and measured the brain activity, showing a positive effect for CET.

Even a very simple training application that works with bare images shows a positive effect for CET (Vollstädt-Klein et al., 2011). Due to the motivation and immersiveness that digital games offer, however, it could be beneficial to transform such an application into a game. While simple games like the ones presented by Boendermaker et al. (2015) have already been examined, the question remains open to what extent a realistic game environment helps. Consequently, this has been identified as the main research question for this project. The focus on a realistic modeling of suitable locations and events is thereby of primary interest. The fun part that comes with a game is secondary but still important. After all, if patients enjoy playing, they will be more open minded towards therapy and keep to it longer. Condensed into one sentence, the question that drives this project is the following:

> *Can a game with a realistic setting that retains the basic mechanisms of CET help to make therapy for alcohol-addicted patients both more effective and more motivating?*

8.3.2. Game Design

More than the two previously presented games, this project was driven by a specific research question. Consequently, the design phase of the game started with relatively strict constraints. Along with further requirements of the ZI how the game should be used, the following list was created:

1. The game should work according to the research question (see above).
2. The main usage scenario of the game should be supervised therapy sessions. However, unsupervised playing should explicitly be supported as well.
3. The game should run on many devices, including PCs, laptops and tablets.

Since the basic CET training application should be mostly retained, a first design decision was to build the game around the actual training. The game thus should be separated into two parts: A story mode and a training mode. The latter should feature some kind of repetitive task where players can train the decisions between alcoholic and non-alcoholic beverages. The surrounding story mode, on the other hand, should be used to let players immerse into the scene and to lead them through the game. Within the entire game, players should reenact situations that could happen in the their daily lives where they are confronted with alcohol. This does not only involve the actual drinking process but much more. For example, a simple walk through the city might be a challenging task because alcohol-addicted patients will unconsciously recognize bars faster than other shops or places to visit. A first idea thus was to create a full virtual world with 3D graphics and virtual avatars, comparable to the *Grand Theft Auto* or *The Sims* games. However, given

the limited amount of development resources available for the project and the lack for a dedicated modeling artist, this idea was postponed.

The approach that turned into the first game prototype still maintained the initial idea, but followed a different approach how to model the game world. Instead of working with a full virtual world, only isolated locations are modeled. These are not based on computer-generated graphics but use real images as basis. Panoramic images are enhanced with interactive elements. Similar approaches can also be found in applications like *Google Street View*[3]. Not only is the effort for creating such scenes much lower than modeling them by hand — possibly falling into the uncanny valley (see Page 66) — but this approach is also lightweight and thus compatible with more devices (e.g., outdated computers). Apart from this, the game idea stayed the same: Players get a list of locations they should visit. In each of these locations, they have to solve a task that could happen in a similar matter in real life. Examples are going shopping, meeting friends for barbecuing or refueling the car at a gas station. Each level starts with a set of panoramic images that finally leads players to a confrontation with alcohol. At this point, the training game starts where players should choose non-alcoholic options out of a set of mixed beverages. Players that choose correctly are rewarded with a positive score that will be saved in a central highscore list. This list is a way for players to compare their results and to increase their motivation to perform better.

8.3.3. Implementation

For the implementation of a first game prototype, a web-based approach was chosen. This satisfied the constraint of platform independence since only a browser is necessary to run the game. A browser is available on nearly any form of device and usually does not have high demands in terms of hardware. Another benefit is that no software has to be installed on the device to run the game, but only a web page has to be opened. Such a low effort makes it easy for patients to run the game on their own devices. Given that the game needs a working connection to the server which hosts the game, collecting statistics about the game is also easy. The only addition that has to be made is to connect a database where the game results can be stored. For this purpose, a separate back-end service was developed. It is responsible for storing user data and analytics data. Moreover, it provides a feedback to adapt the game to the users' skill levels, as described below. Used technologies include HTML5 and JavaScript for the game as well as standard image editing tools and the *Microsoft Image Composite Editor*. The backend service was created using *Python Flask* and *AngularJS*.

Figure 8.11 shows a selection of the game screens. Upon starting the game — that is, opening the web page — players have to login with username and password. This is necessary to match game results to users in the statistics database. Players will then be redirected to the story overview page (see Fig. 8.11a). It comprises two elements: a list of tasks and an interactive map. Each task is linked to a marker on the map. A real map is used for this purpose which is retrieved from *Bing Maps*[4]. For the prototype, the

[3] `https://www.google.com/maps/streetview/`, accessed 29.10.2015.
[4] `https://www.bing.com/maps/`, accessed 30.10.2015.

map shows a view of Germany, and the markers depict a trip from Mannheim to Berlin. However, map segment and locations of the markers can be easily changed as soon as new tasks are added to the game. In the current version, there is also no specific order how the tasks should be executed, so players can pick any task until they successfully finished all of them.

(a) Story overview page

(b) Interactive panorama image

(c) Training game in level “balcony”

Figure 8.11.: Screenshots of the training game showing the different stages of the game.

Each location maps to a game level. A level comprises of a set of interactive panoramic images followed by the actual training game (see Figs. 8.11b and 8.11c). Players can navigate through the panoramic image with the commonly used controls of panning the image with the mouse. Areas where players can perform an action are highlighted by displaying a CSS overlay. These actions mainly include clicking on a certain object/area in the scene to proceed to the next one. Other than that, there are no further elements built into this phase of the game. Its intention is to get players in the mood and to immerse them into a specific scene. Consequently, there is no time limit, and players can freely explore. Upon reaching the last panoramic image and clicking on the respective button, players get a notification that the training game will start now. This mechanism was integrated so that players are not surprised by the following game but can prepare for it.

The game itself is a puzzle game that displays a background image overlayed with images, either computer-generated or excerpts taken from photographs, and/or descriptions of various beverages. The goal for players is to select a certain amount of non-alcoholic drinks. In the default setting, this value is 2. Players score points for right answers and lose points for selecting alcoholic drinks. This game is repeated for a number of rounds. The placement and selection of the beverages is randomized each time so that players are forced to actually look at the objects. To achieve this with the image-based approach, two versions of each game screen were captured: one with beverages and one without. The beverages were then extracted from the first image and placed into the second image in a randomized order. This approach was used to have a bare image without occlusions of the background into which the objects could be added. The beverages were taken from the same scene to have consistent lighting and correct proportions in the final image. After playing all game rounds, players have the choice to either repeat the game — to further train or to increase the score — or to finish it and to submit the score to the statistics database. The final score is calculated based on the answers players gave and on the sum of the times needed for each round.

After playing one or more levels, the players can look at their results on a highscore page. That page retrieves game results from the back-end service and displays them in a highscore list, separated into a global list and one for each level. In addition to this visualization task, the back-end also provides a feedback system for the game itself. It can be used to adapt the game to the skill level of each player. A negative feedback loop is implemented (see Section 3.3.2). It allows to adjust the game parameters so that all players are similarly challenged. The adapted values include the amount of drinks the players have to select, the number of rounds, the ratio of alcoholic to non-alcoholic beverages and the available time per round. Based on the collected game data, the back-end calculates individual player skills for each level and task by using rules that have to be entered by supervisors. These skill levels are used to generate variables for the next game session, resulting in a fine-grained adaption mechanism. While the first game prototype employs no dynamic adaption so far, the back-end service offers a ready-to-use application programming interface (API) which allows an easy integration into the game.

8.3.4. Evaluation

The idea of using panoramic images for creating immersive and realistic environments for the players was developed as a lightweight alternative to fully interactive virtual worlds. While the implementation of a prototype showed the technical feasibility of this approach, an even more crucial aspect is how players perceive such a game/application. For this purpose, a user study was conducted. Instead of performing a long-term study about the actual therapeutic usefulness, this first study was intended to receive an early feedback from potential real users of the game. The basic training application had been examined already, for example by Vollstädt-Klein et al. (2011), so this study concentrated on the added gaming aspects. Usability was the main focus here, and the following categories were examined:

Appeal Describes the visual appearance and the user guidance of the application.

Predictability Relates to a consistent user experience in terms of functionality.

Efficiency Describes how fast users can solve tasks in the game to their satisfaction.

Controllability Rates by how much users feel in control when using the application.

Arousal Relates to the excitement/interest users perceive when using the application.

The second purpose of the study was to find out how players perceive the use of panoramic images in terms of immersiveness and realism. Finally, patients should rate for themselves if they see positive therapy influences by using the game.

Ten patients (8 male, 2 female) that were in active treatment at the ZI participated in the study. They all were categorized as "light drinkers" by their therapists. This means that they are allowed to stay at home over night and just come to therapy sessions to the ZI during the day. As such, this group of patients is a representative sample of the intended target group of the game since the game could be played during therapy sessions as well as in leisure time by the patients. The participants were aged between 24 and 58 years with a mean value of 43.1 years. While six of them use computers on a daily basis, four stated to use computers only up to once a week or less. Moreover, seven out of the ten participants never play computer games and only two play once a week or more often and thus could be categorized as "gamers".

The study consisted of a supervised play session where each player was instructed to play the game once. This included selecting levels on the story overview page, playing five levels with different locations/scenes and looking at the results on the highscore page. The participants could ask for assistance if something unexpected happened. After the play session, they were asked to fill in the questionnaire. Most questions were modeled as a seven-point Likert scale with a neutral answer in the middle and two opposing statements on each side. Thus, results for one specific statement can be interpreted as a value between 0 (neutral answer) and 3 (full agreement for this statement). In terms of usability, results were positive in total (see Fig. 8.12). Each of the 15 questions that relate to usability was then assigned to one of the five categories, with each category consisting of two to four questions. Questions regarding predictability scored best with a mean value of 2.0, followed by efficiency. These results indicate that users had no major problems with using the application in general. This is particularly interesting when taking into account that not all participants use computers frequently. Similar results can be observed with controlling the panoramic images with a mean value of 2.3.

Regarding the actual therapeutic use of the game, questions were asked about the perceived realism and usefulness (see Fig. 8.13). Participants rated the level of realism with a combined mean value of 2.05 which can be seen as an indicator that the used approach as well as the modeled scenes were implemented correctly. The perceived usefulness, however, was rated at a relatively low value of 1.3. Surprisingly, a clear distinction between gamers and other participants could be detected here: Participants who play regularly rated this category much better (mean value 3.0) than the others. Given the subjective impressions of the patients, these answers have to be taken carefully. Patients might assess this approach negatively in the first place even if therapists use it deliberately because they

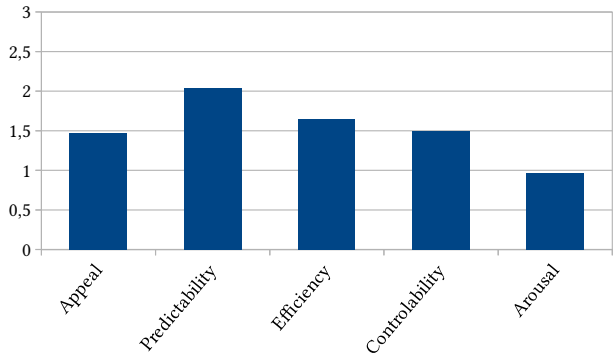


Figure 8.12.: Mean values of the five usability criteria. Each category is composed of two to four single questions and ranges from 0 (neutral answer) to 3 (full agreement for this statement).

might know better what is actually beneficial for the patients' treatments. For example, a patient stated that he actually could taste the alcohol on his tongue when playing the game and thus rated the usefulness negatively. However, CET takes exactly this into account by exposing patients to controlled stimuli, so it could be taken as an indication that the game actually is effective.

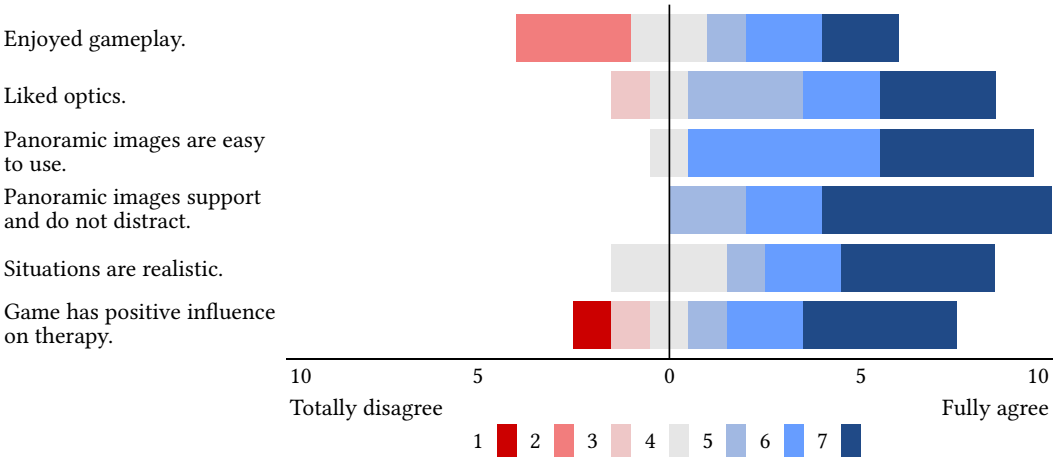


Figure 8.13.: Subjective user feedback of the panoramic approach and the perceived usefulness of the game.

8.3.5. Discussion

This project differs substantially from the other two games presented in this chapter (see Sections 8.1 and 8.2). An obvious difference is the application area which is not education but health. Another important factor is that this game is intended to be used as a training instrument which requires the game to be repeatable. Consequently, this

project started with stricter constraints in terms of requirements and intended usage. Some compromises had to be made in order to develop a game prototype with the limited resources. Participants of the study attested the game good results in usability and the use of the panoramic images. However, more thorough evaluations are necessary, including more participants, to evaluate the actual influence on the therapy outcomes.

Looking at the resulting game design, it can be stated that the given constraints have been met. However, this comes at the cost of not having many game elements other than the training application itself. All the parts around it, namely the story mode with the panoramic images, are merely a way to prepare for the training. Having a highscore is certainly another motivating factor, but it cannot be seen as a real game element on its own. For future improvements of the existing game prototype, it thus would be important to add more game elements without totally sacrificing the explicit training character. Apart from that, the game already offers possibilities to easily add new content. Since the story can be created arbitrarily and at any place, new locations and levels can be added without changing the existing content. This is similar to *Professor Architecto's Quest*. Here, however, new content does not have to be created in a dedicated modeling tool, but it can conveniently be captured with a camera. An idea how to get new images from real places would be to ask patients to take pictures of places they visit themselves. This would not only add more playable content to the game, but it would also allow players to identify even more with the presented scenarios.

8.4. Summary

One of the two central research question of this thesis was in what way serious games should be created to be fun as well as effective. After examining theoretical background in Part I, the foundations of the game design and creation process were presented in the previous chapters. Based on these considerations, a set of games has been developed. All three games feature static serious content. With this approach, serious content and game parts are tightly linked. Consequently, altering either part once the game development is finished is not possible without considerable additional effort. Two of the developed games have been developed with an educational purpose in mind: *Prof. Architecto* delivers knowledge about architecture to young students while *Corruptica* teaches business ethics to University students. The third game, located in the health sector, is specialized to a specific training method, namely applying CET to alcohol-addicted patients in a playful environment.

The basic concepts used when creating serious games with static content do not differ much from the techniques used for creating pure entertainment games: Game designers have to come up with a game idea, including concept, genre and story, and game developers then can implement the game by following an iterative approach. The key difference is the integration of the serious content. Not only should it be integrated into the game idea in a meaningful way, but doing so also requires a proper communication with the domain experts. That process gets all the more complex the more constraint exist at the beginning. This could be observed with the last game presented in Section 8.3.

Overall, the employed game concepts proved to be effective. They included the crucial aspects of the respective learning or training contents while using well-known game design techniques. These findings were additionally confirmed by conducted user evaluations. For example, students that played *Corruptica* reported that they could actually empathize with the ethical decisions managers have to face in the business world. The major drawback of providing such tightly integrated static games, however, is the high development effort combined with the inflexibility to use the resulting game for alternative purposes. The question that remains open is whether games that provide exchangeable serious content can achieve the same degree of effectiveness while lowering the development effort or accessibility of the creation process. These aspects which correlate to the second main research focus of this thesis will be examined in the following chapter.

9. Games with Dynamic Serious Content

Looking at the results of Chapter 8 showed how well serious games can be created when working with static serious content. However, developing these games consumed a big amount of resources. With *Corruptica*, for example, it took over one year to produce a game for one specific topic (see Section 8.2). Such resources are often not available for domain experts such as teachers.

Authoring tools provide ways how to decrease this effort. Particularly specialized authoring tools that allow to change the learning content after the game or framework has been created are a promising way to make the creation process more accessible. However, an immanent characteristic of games that support generic learning content is that they loose the close coupling of game and learning scenario. Yet four games have been developed that are based on this principle. The basic idea to all of them is to provide a fixed game scenario to which custom learning content can be added. They address the second research question formulated in Section 1.1, namely how such tools can be created that result in fun and effective serious games. Furthermore, the question whether they are able to provide as good results as their static counterparts in terms of motivation and learning success should be answered.

9.1. LibChase

This section presents *LibChase*, an educational game for libraries. It is intended to be played by students who should get to know the different services a university library offers. Such services include finding literature in the catalog, learning to cite correctly, or simply to find the different locations of the library. The game mainly uses a gamification approach where different tasks are enhanced with gameful elements such as highscores and achievements. The tasks include location-based elements. Consequently, the game uses a web-based approach that runs on all modern mobile devices and regular PCs/laptops. An authoring component allows library staff to create new learning content based on a set of predefined elements such as a quiz, finding a location or researching for literature. This makes it easy not only to add new content but also to use the game in different institutions with only minor adaptions. The game platform was first developed for the University of Mannheim and includes work done by Wroblewski (2014) and Kissel (2015).

9.1.1. Overview

When thinking of libraries, what probably first comes to mind are old books and a slightly old or dusty atmosphere. This is all but true when looking at the variety of services modern libraries offer. Especially university libraries face the problem that many students do not

even know about the services or how to use them even though taking advantage of them should be an integral part of their studies. This begins at simple tasks such as knowing where on campus the library is located and what the opening hours are. Finding and getting literature is another essential task that every student should know. Additionally, many libraries offer more services such as courses on how to cite correctly in scientific papers or services for printing and scanning. To spread this knowledge, libraries are on the lookout for new ways. A promising way are games with their motivational aspects (Marr and Kaiser, 2010).

Adams (2009) stated that library games are beneficial over the point of just luring more visitors into libraries, but many libraries were still hesitating to employ such seemingly leisurely activities. During the last years, however, more and more activities that bring games into libraries can be observed (Deeg, 2014). Some recent games specialize on isolated tasks. For example, *I'll Get it!* teaches players how to retrieve the correct literature for different search queries. The related game *Within Range* teaches players a specific library categorization system. Other games cover more topics with which students are confronted in libraries. *It's Alive!* as well as *LibHunt* teach students how to use the library services of the respective institutions through a mix of quizzes and small quests. A game that employs more actual game elements is the *ULB-Online-Spiel*. It provides a simple online world where players can walk around with an avatar and have to solve quests like retrieving information and lending books. Broussard (2012) lists more examples for library games in her survey article. She lists six categories how library games can be designed: trivia games, role playing, casual games, games that mix physical and virtual realities, alternate reality games and social games.

Even though there is a variety of library games available already, there is still need for more games in this field. First, specialized games such as *Within Range* can only be used in limited scenarios and mostly by just one specific library. Also, more generic games are mostly not ready to be used by other institutions because of specialized content or just because it is not allowed to distribute them. Second, many games lack a good design. Games that follow a simple linear question style feel more like edutainment applications with all their disadvantages (see Section 4.1.2) than real games. Last, only few games take the physical aspects of libraries into account. Many games require players to lookup information, for example on the library homepage, but they do not encourage players to actually go to the library and explore the possibilities at the location. Existing location-based games, on the other hand, are usually not compatible with the requirements of library games. Common tasks in such games include conquering and controlling territories in real-world locations, like in *Ingress* or *Exploding Places* presented by Flintham et al. (2011). Other game-based approaches are used for finding locations (Ebling and Cáceres, 2010). Tourist guides are another field where location-based approaches are applied to games (Ballagas et al., 2009). When playing with real-world locations it is also possible to let users create their own game contents, like in the game *MobiMissions* (Grant et al., 2007).

There are a few library games that come close to the initial idea of this project. For example, Fitz-Walter et al. (2012) presented a pervasive library game that takes place on the actual campus. It runs on mobile phones and uses the devices' location sensors to

determine the player position and the camera to employ augmented reality elements or to scan QR codes. By targeting younger students, however, the game does not include enough explicit learning content to make it attractive to university students. A gamification application for exactly this target group is *Lemontree*. When using the application, students score points and gather achievements for actions they perform in the library, for example checking in or returning books. Scores are not only counted for individuals students but for the different faculties as well. This game is not easily adaptable to other institutions because it relies on the integration into the real processes of the library (e.g., registering the students' id cards in the library). It also is not a learning application in the first place, but is primarily a tool to motivate students to use the library services more frequently. However, both games offered important insights that were incorporated into the design of the newly developed game.

9.1.2. Game Design

The main goal of the project was to create a game that teaches students new to the University of Mannheim what services the library offers and how to use them. The game *LibChase* evolved around the following research question:

> *How can an educational game be created that teaches students the various services of a university library — including online and on site services — while being reusable for different contents and locations?*

Since knowing the different locations of the library is an integral part of learning how to use it, the game had to be location-based. From this followed that it had to run on mobile devices (i.e., smartphones and tablets). The game design was developed based on these basic constraints.

When determining the basic setting for the game, different possibilities were evaluated. A first decision was whether to follow a fictional story-based approach like in *ULB-Online-Spiel* or not. Given that a location-based gameplay was intended, the decision was made for the latter. Such games have a strong connection to the real world anyway, and since the learning content is very specific it seemed unnatural to employ a fictional story on top of it. Consequently, the game employs mechanics that are also present in games like *LibHunt*. *LibChase* is built out of small tasks players have to solve in order to proceed and to learn something about the library. To increase the motivational potential, however, gamification approaches as found in *Lemontree* were also incorporated. These include rewarding players with experience points for solved tasks, providing achievements and employing a faculty rating for a university-wide competition. Even though the game should not be story-based, tasks should not follow a simple linear layout.

The following game concept was developed: Players are provided with a set of tasks that they can solve in an arbitrary order. Each task comprises of a single element like a quiz or locating a certain book in the library. New tasks can either be retrieved globally or by visiting real-world locations. For example, a player visiting the library at the law faculty will get a task specific for that library. Tasks can be combined to quests for delivering more complex game contents. A quest could include researching a certain book, going to the

library and then retrieving information out of it. This would result in a quest that consists of two quizzes (researching the book and retrieving the information) and a location task (going to the library). Additionally, tasks can either be solvable once (e.g., answering a question about the opening hours) or repeatable (e.g., checking in at a certain library location).

9.1.3. Implementation

Before beginning to implement the game, the decision for either a native or a web-based application had to be made. The former allows for applications that are better integrated into the underlying platform (e.g., Android, iOS, Windows Phone) by providing the native look and feel as well as access to all built-in components (e.g., camera, accelerometer, location sensor). At the same time, applications have to be developed for each platform separately, resulting in high development costs or negligence of potential user groups if not all platforms are supported. Web-based application act as the counterpart to native applications: They are device independent but do not integrate as well. However, recent advancement in the HTML5 standard made access to certain hardware capabilities possible, including location sensor[1] and camera[2]. Since these functions are sufficient to use *LibChase*, it was decided to implement it as a web-based application. A positive side effect was that integrating global highscores became trivial because the game runs on a central web server anyway. The final game consists of an authoring interface that is used to create the game content and the normal game mode. Both components will be presented in the following.

Authoring Interface

Nearly all contents of *LibChase* can be created or changed during runtime. Apart from the design of the game web page, the game is fully dynamic. In contrast to other games that include authoring components (see Section 6.4), content cannot be edited by regular users but only by administrators, for example library staff. To make the creation of new game content accessible to such users, the game offers a set of predefined content types which will be presented in the following.

Visit Location Implements the location-based part of the game. A location can be added by specifying the coordinates of a location and a radius around it. Players can solve such a task if the position of their device matches the defined area.

QR code Search Solvable by scanning a QR code with the decive's camera. This content type can also be location-based if the QR code is printed out and placed at a location. It also has the advantage of working where location sensors are inaccurate or not working at all. A QR code is automatically generated when creating respective game content.

[1] `http://www.w3.org/TR/geolocation-API/`, accessed 04.11.2015.
[2] `http://w3c.github.io/mediacapture-main/`, accessed 04.11.2015

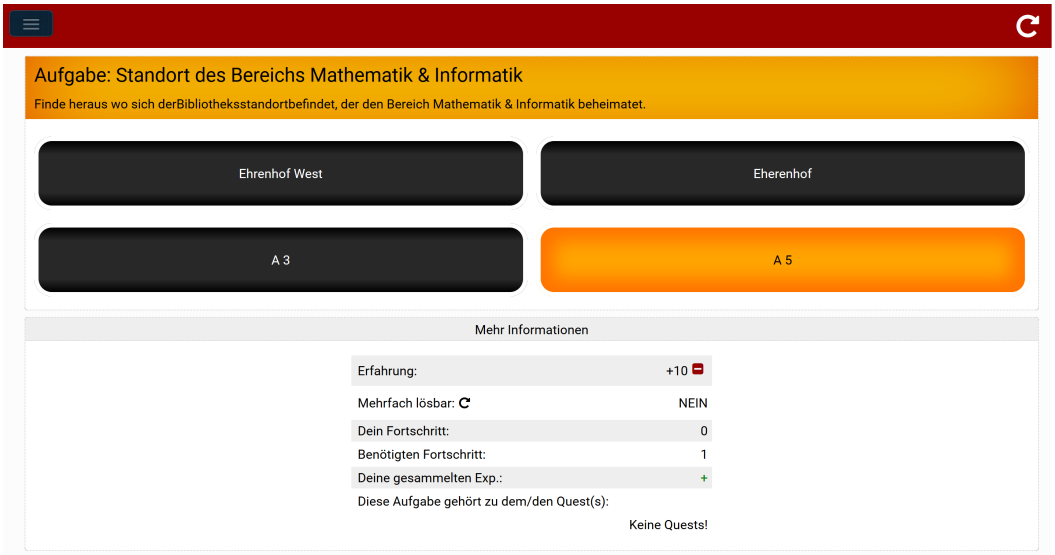


Figure 9.1.: Screenshot of *LibChase* showing a quiz.

ISBN Search Variation of the QR code search content type. Instead of a QR code, a bar code representing an ISBN number has to be scanned.

Quiz A simple quiz with one correct and three wrong answers (see Fig. 9.1). While being standard, a lot of information can be modeled by this content type.

Cloze Text A variation of the quiz content type. Players have to fill in a missing word/-sequence into a given text.

Rate References Works by ordering three elements correctly — marking them green, yellow and red. The main purpose is to rate the quality of citations, but this content type can also be used for other tasks where elements have to be put in order.

An instantiation of a content type — that is, filling it with actual content — is called a *task*. It is the element at the basis for the game players experience. A sequence of tasks can be assembled to a *quest*. Both tasks and quests can be assigned to *badges*. They depict achievements that are fulfilled once all contained elements are solved. Tasks and quests can be assigned to *locations* that can also be created via the authoring interface. Both can have dependencies on each other by specifying predecessors that have to be solved before the following task/quest is unlocked. Furthermore, both types can either just be playable once or be repeatable on a daily basis. This dynamic system offers a high degree of freedom for administrative users, in particular library personnel, to create a wide range of game content.

Game Mode

The game interface — including the authoring interface — is modeled as a fully responsive web site that adapts to different screen sizes. Before playing the game, players have to

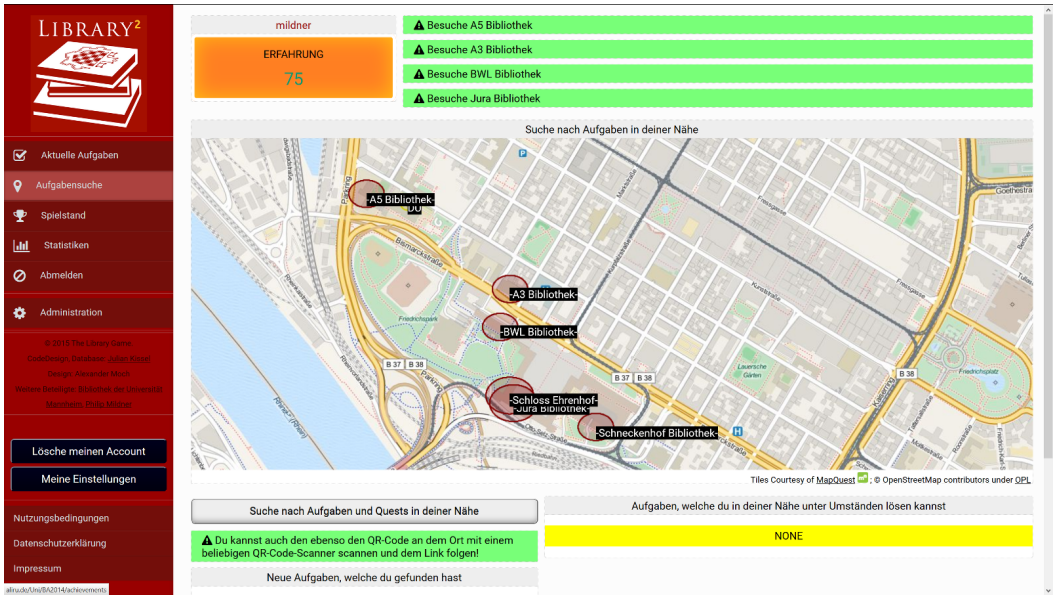
login. They are then redirected to the task overview page. On this start page, all active tasks and quests are listed. Players can work on any of these by simply clicking on them. Depending on the type of content, players either have to select the correct answers or provide their own input, for example when scanning an ISBN bar code. New players will only see global tasks/quests that do not have any predecessors. To acquire new items, players can either solve existing ones that have successors or search for location-based tasks around the campus. This can be done on the map page (see Fig. 9.2a). Given that the player is in range of one of the available locations and there are tasks/quests assigned to it, these will be unlocked for the player if he/she actively checks the position. The active triggering had to be done due to the limitation of the web location API that — in contrast to native applications — does not provide scanning as a background activity. The freely available *OpenStreetMap* material is used to display a real map of the campus.

The other part of the game comprises of the score system. All tasks/quests reward players with a certain amount of experience points. Additionally, players can earn badges by solving a certain set of them or by repeating one task multiple times. For example, there could be a "regular visitor" badge that requires players to check in at a certain location five days in a row or a "traveler" badge that is fulfilled if a player has visited all locations on campus. Players can look at their individual results at the score page. Along with their current experience point rating, the page lists all solved tasks/quests and achieved badges. A second statistics page displays global highscores among players and their faculties. Additionally, a history of the recent activities is shown.

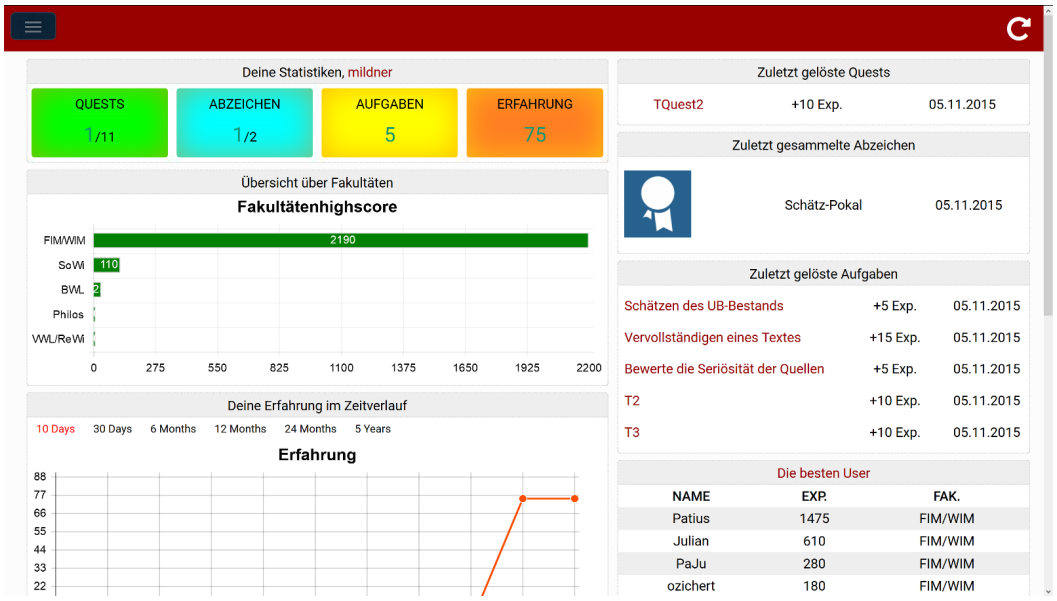
9.1.4. Evaluation

To gain insights on the used development approaches, a technical evaluation of *LibChase* was performed. The game was implemented using an iterative approach, as is common practice in game development (see Section 6.1). This made it possible to actively include the domain experts, namely the library staff, into the process. A first version only included a prototype for the player mode. This allowed testing of the basic game concept. Multiple additions were made to the game based on feedback from the library team at this stage. For example, an anonymous mode was added to the game that allows unregistered players to try out the game. Another change concerned the location-based tasks: Since retrieving the location inherits privacy issues — the location service usually involves sending the own location to the platform provider (i.e., Google, Apple, …) — an alternative should be added to the game. A viable solution was to use the QR code function, since these codes can easily be deployed to all locations, and scanning them does not pose privacy risks. The additional functions were added in a second iteration that also included implementing the authoring component as well as adding refinements to the game mode — including a completely new design and data storage layer.

Based on the second version of the game, an evaluation was conducted with administrative users. About ten users tested the application during a two week period. Since they are responsible for managing the whole game content, the game itself can only work if these users are able to perform the management tasks correctly and efficiently. The player mode, on the other hand, mostly employs commonly used techniques that already



(a) Map view in desktop mode



(b) Statistics view in mobile mode

Figure 9.2.: Screenshots of *LibChase* in player mode.

proved to be efficient in other projects, as described earlier. Feedback was both gathered in interviews and as part of a testing phase. To support this process, a feedback form was added to the game that allowed test users to provide generic feedback, suggestions and bug reports from within the game. In general, feedback was quite positive, and only minor issues with using the system were brought up. For example, users wished for better and more fine-grained feedback when creating new tasks, especially in case of failures or wrong input. Another requested feature was the possibility to edit existing tasks. This was not considered initially, since it could lead to problems when a task is changed after it already has been solved by some players. The solution was to allow editing and testing tasks before they are finally published. Apart from that, only several minor bugs were reported. This positive outcome of the testing phase can be seen as a consequence of integrating domain experts into the development process early. Since they had the chance to shape the game to their liking, beginning with the initial prototype, the second version of the game was already close to the envisioned concept.

9.1.5. Discussion

The goal of this project was to teach players — primarily students that are new to the university — the different services of the university library. To increase fun and motivation, a game-based approach was employed. It combines the learning content with elements often found in gamification applications, such as highscores and achievements. Due to the very specific learning goals with high relevance to the real world — finding a book in the library or rating citations — a simple location-based game was used instead of an abstract story-driven game. An advantage of this approach was that players can not only virtually train how to perform such tasks, but they can actually go to the library and learn the relevant actions there. Players are sent out on a scavenger hunt across the campus where they can discover tasks and quests that lead them to all the different library locations and services. While some tasks can be solved without an interaction with the physical world, like answering a quiz question about the library opening hours, other tasks require players to explore the library and to interact with physical items such as books.

By providing an authoring interface, the game content is completely dynamic. All tasks, quests and locations can be created by administrative staff. As such, it could easily be used by other university libraries. The only things that should be changed within the system are the design, namely logo and color scheme. Due to the generic applicability of the used content types, the game might even be interesting to other institutions. After all, quizzes and location-based tasks can be used for a variety of scenarios, for example tourist guides. It is planned to make the code of the game framework freely available through an open-source license once there is a stable release.

Looking at the experience from the evaluation with administrative users, a mainly positive feedback can be drawn. The game content can conveniently be managed through the same web-based framework in which the game is running. This approach allows the game to run on all major platforms, including PCs, laptops and tablets/phones running iOS or Android.

However, certain limitations were unveiled during the implementation and testing phases. First, running a background service for retrieving the location of the player is not possible with the current HTML geolocation API. This function that is available in native applications had to be changed to an active action players have to perform. Another issue affects the scanning of QR codes. While in theory all platforms should support this feature and demo applications like *WebQR*[3] exist, especially the iOS platform did not allow proper camera access at the time of developing the game. As a workaround, players can take a picture and then upload it. Unfortunately, this function is quite error prone since a single image is mostly insufficient for decoding the QR code. An alternative solution could be to use near-field communication (NFC) instead of QR codes, for example as suggested by Garrido et al. (2011). This approach would avoid problems with the optical recognition, but it might not be as compatible since the availability of NFC-capable devices lacks behind the availability of camera modules. However, it should just be a matter of time until the web APIs are fully supported and the respective function can be re-enabled again in the game.

9.2. Word Domination

This section presents the multiplayer serious game *Word Domination*. The key aspects of this project are to create one fixed game scenario with strong emphasis on motivational aspects and to combine this with a variable learning content. A web-based authoring tool has been created that allows for the integration of arbitrary quizzes into the game. This frees instructors from hassling with game design details. At the same time, it offers players the same level of engaging gameplay by making use of the popularity of 3D shooter games. Apart from the beneficial aspects of in-game learning, the game also offers rankings and statistics, which serve as a motivational aspect on the one hand, and as an evaluation tool for instructors on the other hand. The game has been evaluated and presented at various public events where important feedback was gathered. Parts of this project have been published in (Mildner et al., 2014a).

9.2.1. Overview

Section 4.3.1 argues that learning games are a good way to reach the current generation of students. The design and implementation of such games bears several obstacles, however, as stated in Section 5.1. First, there is a huge gap between entertainment games and educational games in terms of graphics, gameplay mechanics and, most importantly, fun and motivational aspects. This is not surprising at all when comparing the budgets and the development effort. Modern entertainment games compete with Hollywood movies in terms of costs, and big game companies are involved. Educational games, on the other hand, mostly are developed by small teams for a much smaller audience. This includes commercial learning games that, among others, can be used for the acquisition of foreign languages, or for learning maths. Many games are developed with an even smaller budget

[3] `http://www.webqr.com/`, accessed 05.11.2015

in academic settings like the ones presented in this thesis. This results in the fact that many available educational games focus on the correct integration of the learning content, leaving the fun part of the game behind, or vice versa.

Chapter 6 presented different ways how to create serious games. A possibility to utilize the motivating characteristics of entertainment games is to use commercial of the shelf games in an educational setting. Studies have shown that games such as *SimCity*, *Civilization* or *Age of Empires* indeed can be used for delivering learning content (Charsky and Mims, 2008; Prensky, 2007; Squire, 2005). However, teachers are restricted to the exact settings the game provides. To mitigate the problem, authoring tools have been created. These tools allow non-professional game designers to easily create custom-made games with an arbitrary learning content (Göbel et al., 2008). Similar storytelling frameworks like *Alice* or *Scratch* are also used in education to let students create their own stories or games (Kelleher and Pausch, 2007). Again, a problem with such tools can be to correctly combine learning and fun parts, so analyses have to be carried out to find the right balance between the entertainment game and the learning application (Maciuszek and Martens, 2012). Then again, specialized authoring tools seem to be a viable solution to allow non-professional game developers to create games with an adapted content without having to cope with programming or game design considerations. The availability of these tools is still underrepresented, but they would be a good way to mitigate the problems stated above.

9.2.2. Game Design

In contrast to projects that involved an external partner, *Word Domination* originated as a research project. Based on the problems stated in the previous section, the game evolved out of the following research questions:

> *How can the reusability of learning games be increased by offering an authoring interface that does not require any knowledge about programming or game design? And when creating such a learning game, how close can it be to well-known entertainment games without sacrificing the explicit learning character?*

From these questions, several constraints followed: The game should be based on a game principle often found in pure entertainment games, the characterizing goal should be learning, the game should include dynamic content and entering this content should not require any changes to the core game logic. *Word Domination* has been primarily designed to be used by students in schools and universities. Consequently, a main goal of the game was to provide players that are used to playing computer games on a regular basis with a familiar setting. In the following sections, the design considerations that were taken into account during the design of the game are presented.

Game Genre

According to the Entertainment Software Association (2015), FPSs are the second most popular video game genre in the U.S., only superseded by other forms of action games.

The social interaction in shooters has been identified as the primary engagement factor of the genre. Gamers enjoy collaborating in a team and communicating with other gamers. As shooters are highly interactive and dynamic, they are cognitively demanding. For example, they require the player to track rapidly moving objects and to identify them as opponents or team members in a complex environment (Colzato et al., 2010). Combined with difficult challenges, the mastery of moving the character and simultaneously watching for opponents generates a feeling of control, competency and efficacy. This, in turn, contributes to the flow state that creates a deep immersion and a feeling of pleasure for players of shooter games (Colzato et al., 2010; Frostling-Henningsson, 2009). Additionally, the game genre has a strong emotional appeal in that it provides a space for acting out behaviors and experimenting with identities (Jansz, 2005).

A specific game mode of online FPSs was chosen for *Word Domination*: the game mode "domination" — also reflected in the name of the game. *Unreal Tournament* was the first game to use this mode, but games like *Call of Duty* or *Battlefield* have similar game modes. Two teams of players compete over the domination of a virtual map by conquering and holding platforms or checkpoints. In order to win the game — that is, conquering all platforms or scoring enough points by holding the majority of them — players of each team have to cooperate. This introduces another interesting aspect when in comes to the learning goals of the game, namely cooperation. While most FPSs include violent acts such as killing enemy players, such actions are not included to retain the character as learning application. Instead, players can hit each other with simple balls. If a player gets hit, he/she gets frozen and has to answer a question in order to continue with the game.

By focusing on the highly motivational aspects of shooter games and combining them with a variable learning content, *Word Domination* aims to create an intrinsically motivating experience that serves a purpose beyond entertainment. The scenario suggests that the game is mainly targeted towards typical "hardcore" gamers that are used to playing complex games on their computers or gaming consoles. However, the game is suited for a broader audience, too, by providing different ways how the game can be played, as described below.

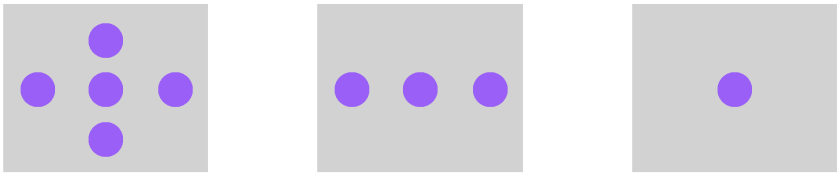
Motivational Elements

Word Domination includes a series of elements that were integrated to make the game more interesting and appealing to players. This includes a reward system, support for different player types, and challenges players have to solve.

Rewards In many situations, players are rewarded or punished with points. These points are entered into a database and are used to create rankings and player-specific statistics in an online highscore. Additionally, the question record for each player is stored, which can be used in an evaluation to display the question catalogs on which players performed best or worst. On the one hand, this is an important evaluation tool for instructors who are enabled to identify strengths and weaknesses for each player. On the other hand, the score system can be an effective reward mechanism that motivates players.

Player Types As *Word Domination* is a competitive 3D shooter, it offers the most attraction for the "killer" and "achiever" player types formulated by Bartle (1996). However, there are some additional elements that might appeal to other player types as well, and the game could easily be enhanced in many regards. Explorers, for instance, might enjoy the game more if maps are dynamically created and platforms have to be discovered before they can be conquered. Socializers might find the game appealing due to the cooperative element in it.

Challenges As the game is a team-based multiplayer game, the challenge for each player somewhat depends on the own team's and the opposing team's skills. To allow for an adaption of skills, different shot modes are integrated into the game: shots that make it easier to hit an enemy contain an easy question, and vice versa (see Fig. 9.3). Novice players should choose to shoot easy questions, which will result in five bullets, therefore making it easier for them to hit an opponent. At the same time, players can choose what goal they want to follow. Players that are experienced in 3D action games might try to capture and freeze many players of the opposing team with hard questions. Other players might try to excel in the supporter role by answering questions for their teammates. In this way, the game offers challenges to different player types.



(a) Five bullets, easy questions

(b) Three bullets, medium questions

(c) One bullet, hard questions

Figure 9.3.: Overview of the different shooting modes in *Word Domination* and their corresponding question difficulty.

Application Areas

The fact that the learning part of the game is a quiz makes it applicable for many subject fields and different teaching methods. In a school environment, for instance, teachers might create a set of questions on a certain subject in order to have students review the lesson's content or to prepare students for an upcoming exam. In a different approach, students might benefit from thinking of questions and answers on their own or in group work. Additionally, students might be intrinsically motivated to play the game in their leisure time with their peers, which would lead them to dealing with their learning content more than by playing other video games. By examining the online statistics, players and teachers can identify each player's strong and weak subjects and devise strategies in order to improve them.

9.2.3. Implementation

Word Domination is a round-based online 3D shooter. It has been designed to incorporate the engaging game elements of multiplayer action games as well as the knowledge transfer of a generic quiz. By design, the resulting game had to be a trade-off: As the game should support any learning content that can be modeled as a quiz, it could not be tailored to one specific scenario like, for example teaching maths skills or learning foreign languages. Instead, the learning content has been integrated in a way that allows to use the same gaming scenario for different learning topics.

The game client is implemented with *Unity*. The *SmartFoxServer* framework was chosen for the server side because it offers easy-to-use game server functionality that can be extended with own extensions. The game server is connected to a MySQL database that stores the question catalogs as well as the game and player statistics. The web site connects to the same database, so question catalogs are consistent between game clients and server at all times. It has been created with the web framework *CakePHP*.

Rules

Upon entering a game room, players choose a character and are subsequently assigned either to the red or the blue team. Thereupon, players are released into a realistic 3D environment which they experience from a first-person-perspective (see Fig. 9.4). As in traditional first-person shooters, players can control their avatar by moving in all horizontal directions, as well as jump and run.

Players can choose between different levels of difficulty that are modeled as different kinds of bullets: If a player chooses to ask easy questions, there will be five bullets for each shot, making it easier to hit the opponent, while medium questions will result in three bullets, and for a hard question only one bullet will be released. If a player's avatar gets hit by a question, the avatar will be captured in a sphere for a certain time period unless the player manages to answer the question correctly within that time frame. If he/she does not know the answer, players have the opportunity to ask a nearby fellow team member to answer the question instead. This introduces cooperative mechanics to the gameplay. For orientation, a mini-map displays all the player positions on the map. It will switch parts of the map to red or blue if a player conquers a platform. In addition to six platforms that can be conquered, the first map includes some strategic elements, such as a lake in the middle that divides the north from the south and a destructible wall in the middle of the map. Furthermore, two "boosters" are placed on the map that will catapult players' avatars from one corner of the map to the other, making the game play highly dynamic and unpredictable. A scale that ranges from blue to red indicates which team is in favor of winning the round. If one team has conquered more platforms than the other, the pointer will move along the scale towards it (see A in Fig. 9.4). As soon as it reaches the end of the scale, the respective teams wins this game round.

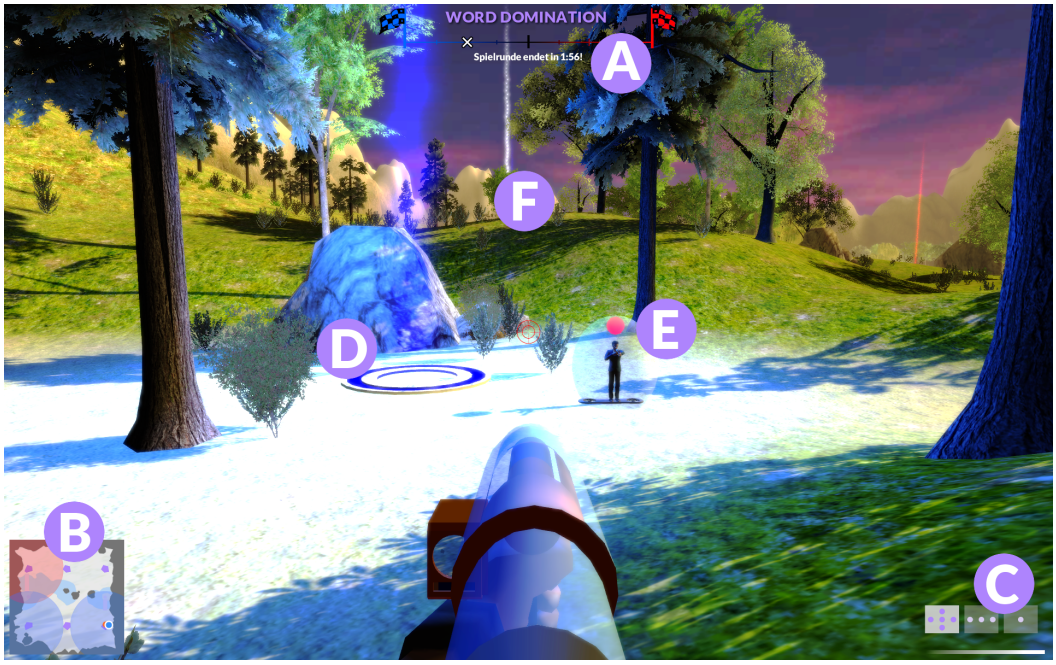


Figure 9.4.: Ingame screen showing the leading team scale (A), the minimap (B), the shooting mode selector and the running bar (C), a platform captured by the blue team (D), a red player captured in a question sphere (E), and neutral platform indicators (F).

Web Interface

In order to offer variable learning content, a web application has been developed that enables registered users to create question catalogs. Within a question catalog, users can create questions and answers related to a certain topic. On completion, the question catalog can be chosen in the room creation process of the game, and its questions will be displayed when players are hit. A question that only contains one answer will be displayed as a text field in the game, whereas many answers, at least one of which must be correct, will result in multiple choice check boxes within the game.

The web application offers further functionality in that it displays user rankings and detailed user statistics, as well as game logs. The highscore displays the ranking of all active players. The scores are calculated by adding up all values that are collected from the game sessions. These include how often a player hit other players, how he/she answered questions, how often a player conquered a platform, and whether a player won a game (see Fig. 9.5). These values can be viewed in detail for each player, including an overview how the player performed for each covered question catalog. In addition to this, the web application offers detailed games statistics that show every hit and the associated

question as well the history of the conquered platforms. The web interface along with the downloadable game client is publicly available.[4]

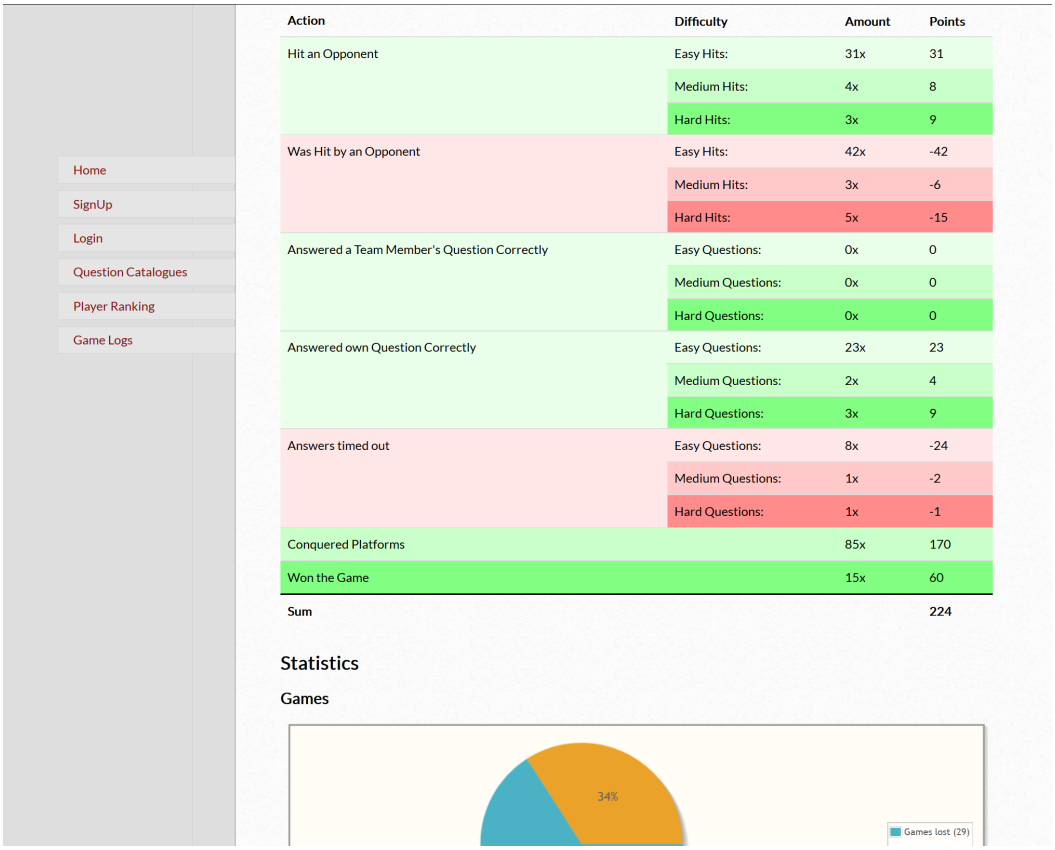


Figure 9.5.: Screenshot of the web interface showing parts of the detailed statistics for one player. Other pages like the editable question catalog and detailed game logs are accessible through the menu on the left side.

Extensions

After the implementation of a first prototype, the game has gradually been enhanced and improved. For example, in the initial version all platforms had to be conquered by one team to end the game. Testing this approach revealed that this situation is very hard to achieve if both teams are more or less on the same skill level. The winning conditions were thus changed to a score-based system: Each conquered platform generates points for the respective team. The game is won by the team that reaches the point limit or has the higher score when the game ends after a predefined time span. The graphics of the

[4] `http://www.knowledge-gaming.de/games/word_domination/`

game were also completely redone in conjunction with upgrading the game client to a new major version of *Unity* (see Fig. 9.6).

Apart from the minor extensions of the game mechanics during the initial development, *Word Domination* can be further extended. This is possible on three different levels: the learning content, the game client and the game server. Obviously the integration of new learning content is trivial as it only requires running the game client and adding new questions to the catalog through the web interface. No implementation effort is necessary for this task — after all, the game has been designed exactly for that. If game creators want to add new game levels (e.g., a level that is connected to a specific learning content), changes to the game client are necessary. While the implementation effort is low, the new level has to be created in *Unity*, requiring both knowledge in 3D modeling and game design. Changes to the core game mechanics require further implementation effort. For example, to integrate different learning content other than quizzes, client, server and web site would have to be changed, resulting in a comparatively high implementation effort.

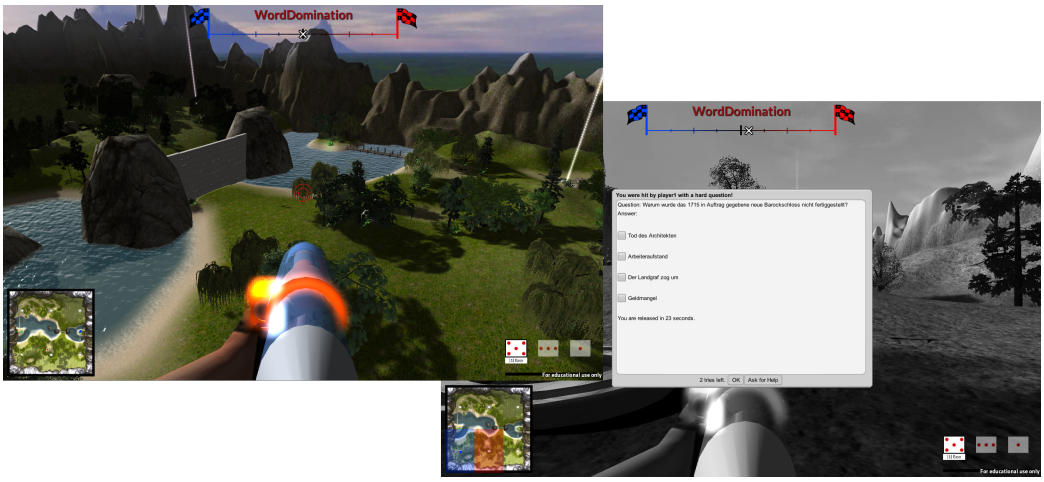
9.2.4. Evaluation

While the integration of engaging gameplay and a variable learning content into *Word Domination* promised good results in theory, the actual implementation needed to be testified by studies and qualitative feedback. Results were gathered in two studies and several public demonstrations of the game.

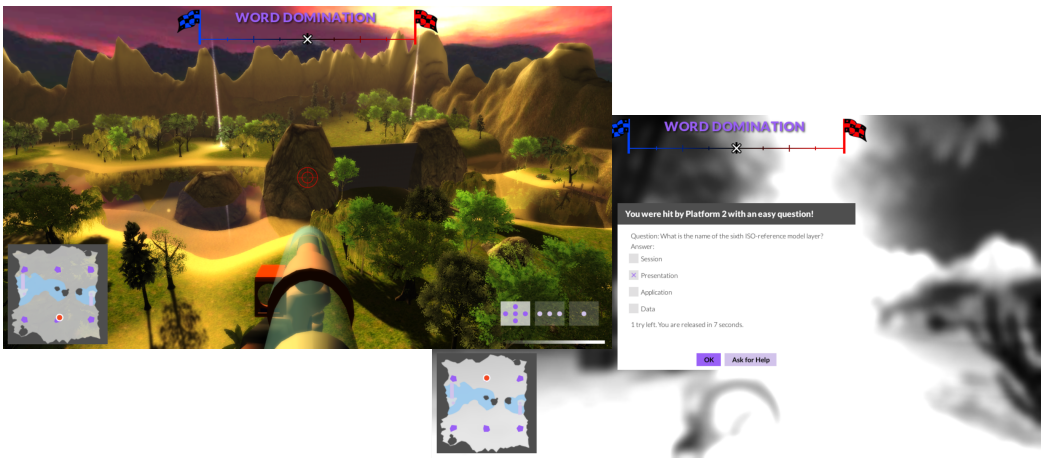
Preliminary User Study

A first evaluation of the game was carried out as part of a lecture at the University of Mannheim. Six master students — all male — in the business informatics degree played the game with quiz content related to the course "Advanced Computer Networks". After playing, they were asked to share their experience in self-evaluation by filling out a questionnaire. The first part of the questionnaire focused on game mechanics, such as challenge difficulty, game speed and character control. The second part aimed to identify which elements of the game were perceived as motivating by the players. Questions focused on the flow experience (concentration and immersion), the social aspect (multiplayer), rewards (online rankings and statistics), challenges, goals and graphics. The final part of the survey included questions related to whether the game was seen as a suitable learning tool. The answer possibilities to each question were weighted.

In terms of game mechanics, participants were only intermediately satisfied with the game (see Fig. 9.7). Additional comments were that players had problems with the controls (e.g., mouse sensitivity and identifying players as friends or foes) and that they were not impressed by the graphics. If *Word Domination* is compared to contemporary games this is somewhat understandable, as modern 3D shooters offer high-definition graphics, a range of customization possibilities, and elaborate character controls. Motivational aspects, on the other hand, were assessed more positively. This leads to the assumption that games might not necessarily need to incorporate the best graphics in order to motivate the players. That assumption is reinforced by the fact that all players enjoyed playing the game and that



(a) Graphics and GUI in the first version of the game



(b) Graphics and GUI in the updated version of the game

Figure 9.6.: Graphics comparison of *Word Domination*.

the majority would use it for complementary exam preparation. Most of the participants also agreed that the game would be beneficial as an exam preparation tool, especially if played in relaxing breaks of studying. The vast majority disagreed that the game would be an unnecessary distraction during exam preparation, and that playing and learning can not be combined.

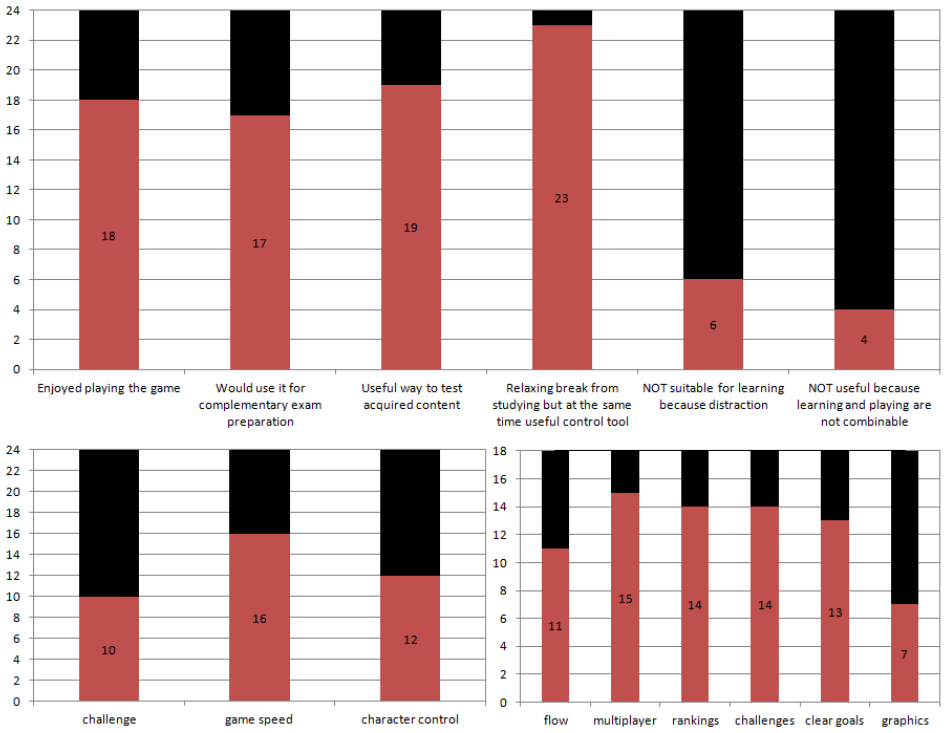


Figure 9.7.: Results of the university study. Numbers in red bars show the weighted score of approval for a question whereas black bars show the amount of disapproving answers.

As a consequence from the negative results regarding the game mechanics, several changes were made to the game. A first improvements was updating the graphics as shown in Fig. 9.6. Another essential change to the internal game logic was moving main parts of it to the server part since the evaluation had also revealed major consistency problems when the game was played by four or more players. Other minor changes included a function to adapt the mouse sensitivity and making the avatars more distinguishable. In sum, the results of this evaluation were promising and enabled the further development of *Word Domination*.

Public Demonstrations

Due to its applicability to different learning contents, *Word Domination* was used in various public demonstrations. The game was presented at the GameDays 2013 Rallye in

Darmstadt, Germany, with question about the city of Darmstadt. At the Schlossfest at the University of Mannheim in 2014, the game was presented with questions about the festival event and the university. Another demonstration was done at the event "Mannheim macht schlau" in 2015 at the *Technoseum*, a technical museum in Mannheim. In total, over 150 people of all ages and diverse backgrounds played the game. Figures 9.8 and 9.9 show some impressions of the events. In general, the game received positive feedback, and most of the players stated that they had fun while playing. However, some of the players' comments and further observations led to additional lessons learned, as presented in the following.

Figure 9.8.: Impressions of a game session with *Word Domination* at the Schlossfest Mannheim 2014.

First, the classic way of controlling a character in a 3D environment with the keyboard and mouse can by no means be presupposed. A substantial part of the participants, regardless of age, did not know about this way of controlling the character, and especially had problems with the coordination of moving and simultaneously looking in the right direction. However, children were much faster than adults at understanding the controls and at learning how to effectively move around in the environment. This is an expected confirmation to the theory that individuals who grow up surrounded by technology will be quicker at grasping new concepts and at easily adapting to their usage. So, in order to provide common starting points for all players, a 3D game should introduce gameplay mechanisms with preliminary tutorials and support struggling players with in-game help mechanisms.

Apart from problems related to controls, a few participants saw the act of shooting an opponent as hostile and refused to play the game. It should be noted that *Word Domination* does not include any display of violence or death, and guns are represented in a non-realistic manner, which makes the game comparable to paint ball rather than to a war simulation. Nevertheless, the mere activity of aiming and shooting at somebody had a repelling effect on several players.

Third, some players remarked that the flow of the game sometimes was disturbed for them because of speed changes. The game speed is very high while players move around in order to conquer platforms, hit opponents and avoid being hit. When trapped in a question,

Figure 9.9.: Impressions of a game session with *Word Domination* at the "Mannheim macht schlau!" 2015 public demonstration day.

however, the speed suddenly becomes very slow, and a great deal of concentration and patience is required. Several players experienced the fundamental difference of the two tasks as obstructive to the experience of game flow.

Last, the diversity of players concerning their demographic background yielded unexpected results. The game was primarily attracting male players beginning at an age of about eight which was expected. When there were children accompanied by their parents, however, the following phenomenon could be observed repeatedly: Children were far better at controlling the game than their parents, but when it came to answering questions the parents were usually in advance. A common approach was thus that children were controlling the character and parents were responsible for answering the questions. This enabled a cooperation not just between the players of the game, but it allowed players and bystanders to interact and learn from the game.

9.2.5. Discussion

Creating a game that can compete with commercial entertainment games in terms of player engagement and at the same time offer generic content was the goal of this project. The implemented game *Word Domination* combined the engaging gameplay of multiplayer shooter games with the universal learning content of a quiz. The game has been developed as a specialized authoring tool where users can create accustomed game rounds without having to cope with game design considerations. The strict separation between game and learning scenario proved to be advantageous for all involved parties: Game designers can focus on creating a game that is highly motivating and fun to play. Teachers or instructors, on the other hand, can concentrate on integrating just the exact learning content they intend to use. In *Word Domination* this has been implemented by providing a web-based authoring tool that can be used to create arbitrary question catalogs but does not change the overall game scenario. Finally, players benefit from this by playing a learning game that has been optimized both for fun and learning.

The game was tested and evaluated at various occasions. This includes user studies as well as public demonstrations of the game. A first testing session showed the applicability of the used approach, but it also revealed some weaknesses — including weak game controls and graphics — that were improved in later versions. The game was also used in multiple public demonstrations. While specific statements about the learning outcome could not be made there, other valuable aspects could be observed. Despite a small percentage of visitors that disliked the used game genre as a whole, players were generally pleased by the game. However, the game mainly attracts young male players. To attract more diverse player types, more features like different roles could be added to the game. For example, players that are not experienced with shooter games could take the role of supporters that coordinate and assist team mates in answering questions. A more fundamental weakness of the game was revealed during the play sessions as well, namely a break in the game flow when answering questions. The reason for this are the different paces of the two main actions in the game: While the game itself is action-heavy and asks for fast interaction, answering questions is a reflective action that requires concentration. In a way, players are thus punished for thinking about a question for too long. Pausing the whole game while answering question is not an option either since the game is multiplayer-based. Possible solutions to this problems would be to integrate the processing of questions more deeply into the game. Instead of only showing a GUI window, players could perform an action within the game world — for example, shooting objects that represent the correct answers — to stay in the flow and pace of the game. This would only be an incremental improvement that would not require changes to the main game concept. Looking at the otherwise positive responses to *Word Domination*, providing games with specialized authoring tools can thus be seen as a viable solution to make the game creation process more accessible to users that do not have a game design or programming background.

9.3. The Mannheim Game

This section presents *The Mannheim Game*, a game about the history of the city Mannheim. The primary goal with this game was to teach the history of the city, and to make this topic more accessible to younger audiences. At the same time, a game is a good platform to build interactive and immersive environments that make historic facts more tangible to all users. The game was created based on the existing framework provided by the game *Word Domination* which was presented in the previous section. The new game was specially designed to incorporate the actual history of Mannheim and features a realistic scenery of the city in the late 18th century. Based on the implemented prototype, a comparative user study was performed. It tested the game against a non-gaming-based teaching method to evaluate the potential benefits of the game.

9.3.1. Overview

The project originated out of a collaboration with the *City Archive Mannheim*[5] and includes work done by Beck (2015). The archive possesses a large fund of historical material from the history of the city, including books, protocols, drawings and photographs. An important matter is not only to archive all the material, but to make it accessible to the public. In order to reach a large audience, different presentation forms are explored, including games. The primary use case for such a game is to use it with school classes as part of an exhibition visit. This has several potential benefits. First, games are popular in this age group, and students respond to them more positively than static material such as drawings. Second, games allow to model believable and interactive virtual environments. Players no longer take the role of mere visitors, but they become actors in the environment the game provides. This leads to a deeper involvement with the respective topic and potentially to a better learning outcome.

A variety of projects exist that deal with delivering knowledge about cultural heritage. Many base on providing realistic 3D environments of cities in historic settings, including *DentroTrento* (Conti et al., 2006), *RomeReborn* (Frischer et al., 2008) and the *MediaEvo Project* (De Paolis et al., 2011). While these applications include interactive elements, they do not incorporate dedicated game mechanics. However, with the increasing popularity of entertainment games and available technologies (e.g., easy-to-use game creation tools), more and more cultural heritage games are being developed (Anderson et al., 2010; Mortara et al., 2014). *Gates of Horus* is a related game set in the ancient Egypt (Jacobson et al., 2009). Just like *The Mannheim Game*, is was primarily designed for students. A comparative study was conducted with students where the effects of the game were examined, showing that it actually had positive influences on the students' learning outcome. Regarding the aspect of making the creation of such games more accessible, Bellotti et al. (2012) presented an authoring framework specifically made for creating cultural heritage games. It includes the creation of the virtual environment as well as the inclusion of game elements such as quizzes or finding differences in a set of pictures. Other projects take the connection to present times into account by applying a mixed reality approach. For example, in the mobile game *TimeWarp*, historic sights of buildings or places are blended with their modern appearances with the use of augmented reality techniques (Herbst et al., 2008).

The high availability of cultural heritage games shows the relevance of this topic. However, existing games cannot simply be reused since especially this game genre depends on realistic representations of the historic sights and events. Therefore, a new game was created that includes content specific to the history of the city Mannheim.

9.3.2. Game Design

Since the game was created with a specific usage scenario in mind, some constraints for the game design phase could be determined right at the start. First, the main target group of the game should be students from middle school or high school. Providing a game for this age group promised the best effects of making the exhibition interesting for broader

[5] `https://www.stadtarchiv.mannheim.de/`, accessed 05.12.2015.

audiences. Second, the game should be usable as part of a museum exhibit. Interviews that were conducted with teachers revealed that the available time span for playing the game should not exceed 15 minutes. Reasons for this limit are that the time of a museum visit is limited and students of that age group will lose focus in the current activity quickly. Last, it was decided to set the time epoch of the game to the end of the 18th century. This period after the French revolution was turbulent for Mannheim, since the city was conquered by French troops in 1795, and only shortly after this event Mannheim was reconquered and largely destroyed by Austrian troops (Nieß and Caroli, 2007). At that time, the city was still surrounded by city walls and looked much different to what it looks like today. Based on the formulated constraints, the following game concept was developed:

> *In the year 1794, the city of Mannheim is awaiting complicated times: Only a few year after the French revolution, French troops have been spotted on the other side of the Rhine river and rumors are that the city is about to be attacked soon. The cityscape is characterized by the presence of soldiers, and a tense atmosphere is all around. In fact, French spies are already present in the city, trying to find weak spots in the city defense. Their mission is to find plans with valuable intelligence information. However, this endeavor has not been unnoticed by the local authorities, and German spies have been sent to the city to secure the plans before the enemy gets to them. To reveal the identity of the enemy spies, both factions try to attract the attention of the Mannheim city guards by throwing fireworks at each other. A caught spy will have to answer a question about Mannheim to prove that he/she is a real Mannheim citizen; otherwise the prison awaits. The outcome of this spy thriller will decide about the fate of Mannheim.*

The story concept allowed to embed a set of game mechanics. A FPS multiplayer game acts as foundation where players of two teams take the roles of both factions, that is, German and French spies. The employed game mode resembles the well-known "capture the flag" mode. In this mode, each team has to secure its flag and bring it back to the team's base. The Mannheim Game uses a slightly adapted version, since there is not just one plan for each team, but there are multiple ones that each team can secure. Instead of incorporating violent actions as most action multiplayer games do, player are just allowed to throw small fireworks at each other in the game. This action is historically relevant since fireworks were banned from the city at that time, and using them would actually have called the attention of the city guards.

Two main learning aspects are integrated into the game. The first one is the whole virtual environment the players experience. They are able to walk through a historically correct representation of Mannheim in the 18th century. This should help memorizing the impressions more than reading books or looking at drawings. The second learning aspect comes into play when players get caught and have to answer a quiz question. Other than the game level, the questions are not static and can easily be changed. For example, it would be possible to adapt the question set to the current exhibition or to a certain aspect of the history of the city.

9.3.3. Implementation

The implementation of *The Mannheim Game* builds up on the already existing platform that had been developed for *Word Domination* (see Section 9.2.3). This was possible because both games have many commonalities: Both are action multiplayer games, and the game modes differ just slightly The two games also incorporate quiz questions as learning content. Consequently, only the differences and necessary changes will be highlighted in the following.

The most visible change is the implementation of a new game level. Instead of the abstract level from *Word Domination*, a new one was designed that resembles parts of the inner city of Mannheim as it looked like at the time the game is set. The castle was picked as main area (see Fig. 9.10a). Not only is it one of the main sights in Mannheim, but it is also one of the few buildings that still exist today. By using this building, players have the possibility to compare both the historic and today's appearance, leading to a higher identification with the history of the city. Great care was taken in order to model the castle and its surroundings realistically. Most of the models were created manually in a modeling software. Both artificially generated images and photographs were used as basis for the models' textures. These were further improved by tools like *AwesomeBump*[6] to make the textures look more realistically.

Concerning the game mechanics, only minor modifications had to be made. Instead of having static platforms that are placed on the map, movable plans were added to the game. These can be picked up by players and brought to the teams' bases which were added with a visual representation as well (see Fig. 9.10b). The shooting mechanism was adapted so that players throw with fireworks instead of balls. Furthermore, new player models and a GUI were integrated that fit into the historic setting of the game.

For the integration of the learning content (i.e., quiz questions) no implementation work of any kind was necessary. This feature could directly be used from the original *Word Domination* game by just adding a new question catalog and questions. This task was done by the domain experts from the city archive who could directly enter the questions into the web interface.

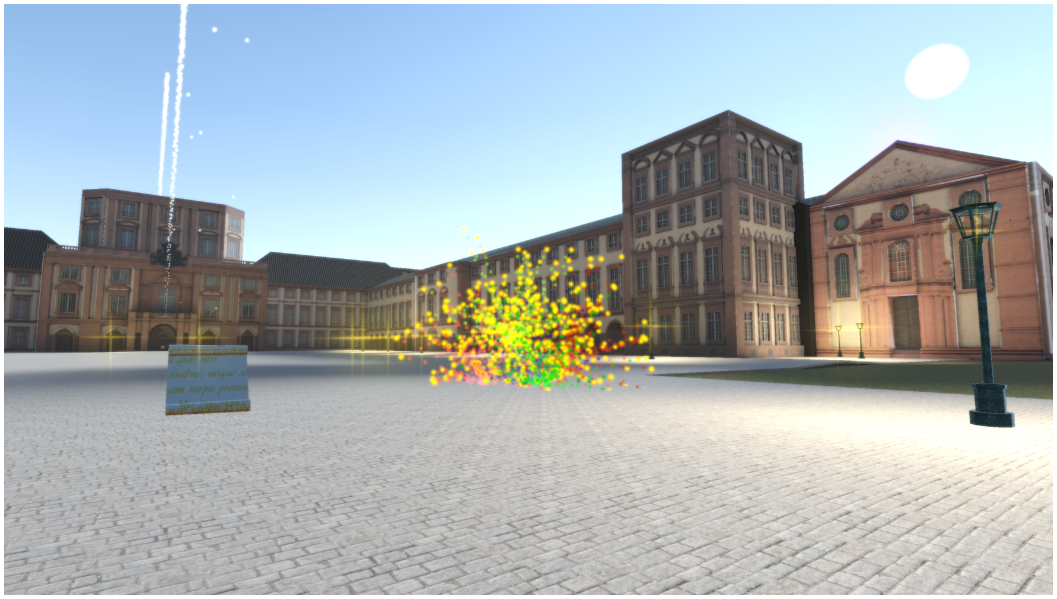
9.3.4. Evaluation

The different presentations of *Word Domination* already showed that the base game concept works well (see Section 9.2.4). Players had fun and enjoyed the mix of action game and quizzes. However, the question whether the game yields actual positive learning effects could not be answered so far. For this reason, a comparative user study was performed with *The Mannheim Game*. The following research question was asked:

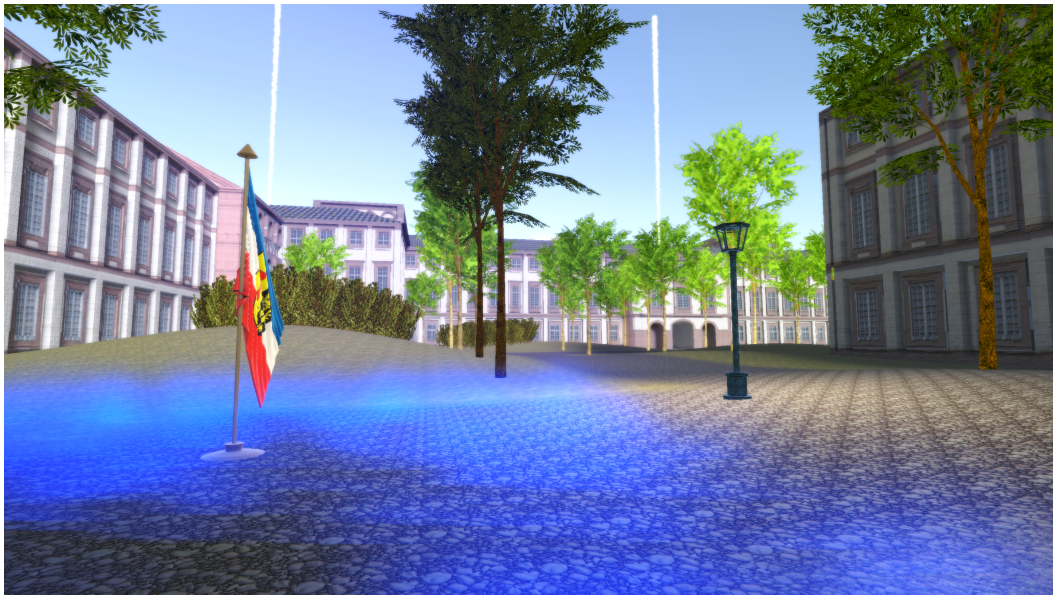
> *Will playing* The Mannheim Game *lead to a better memorization of learning content than acquiring the learning content with non game-based methods?*

To examine this aspect, two classes of the 10th and 11th grade from a secondary school in Mannheim participated in a study. In total, 39 students were randomly assigned into two

[6] `http://awesomebump.besaba.com/`, accessed 02.02.2016



(a) The castle with exploding fireworks and one of the plans in the foreground.



(b) The Mannheim base in the castle grounds.

Figure 9.10.: Screenshots of *The Mannheim Game* with the level that features a historic setting of the castle in Mannheim.

groups, A and B. At the beginning of the evaluation, both groups got informative material, consisting of text and images, about the history of Mannheim in the 18th century. The 19 participants of group A had ten minutes to read and process the material. After that, they had some free time in which they could either further work with the provided material or do something else. Group B (20 participants) only got five minutes for this task. Following this, however, group B got to play three game rounds, resulting in a total game time of 15 minutes. After each group was finished with the tasks, the participants were asked to fill in two questionnaires. The first one included questions related to the subjective impressions on working with the text. Additional questions were added for group B that concerned the impressions with the game. In the second questionnaire, students had to perform a test with quiz question about the learning content that they just worked on.

Questions A1 and A2 were related to the processing of the text. Since both groups got the same text, a comparison between the groups could be made. Results show that all participants show the same tendencies in the assessment of processing the text with slightly stronger opinions — resulting in a higher variance — in group A (see Fig. 9.11). The remaining questions B1–B6 of the first questionnaire were only answered by group B because group A did not play the game. In general, players were very pleased with the game, both in controls and enjoyment, even though not all players rated themselves as frequent users of computers or computer games (see Fig. 9.12). These results confirm the impressions that were gathered during previous demonstrations of the game. A majority of players also agreed with statement B6 that the game increased their interest in the learning topic with a mean value of 4.7.

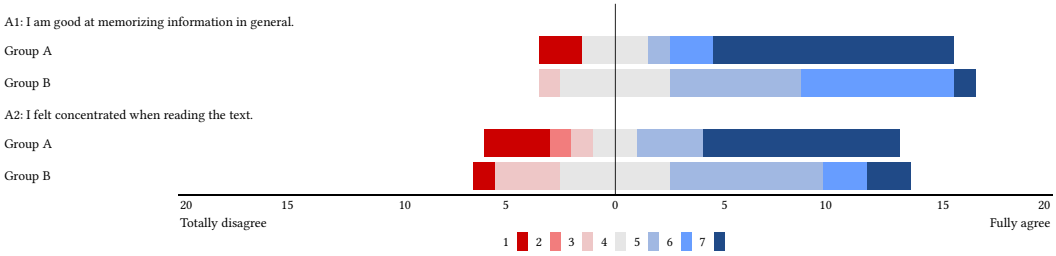


Figure 9.11.: Comparative results of text processing for groups A and B. The bars show the distributions of the seven point Likert scale.

The second questionnaire contained questions about the learning content, namely the history of Mannheim in the 18th century. The answers to seven questions (C1–C7) could be found in the text as well as in the game. In addition to that, there was one question that was only answered in the text (D1), only one in the game (D2) or in none of the two (D3). These served as control questions. Figure 9.13 shows the rate of correct answers. Given that the content of question D3 was not in the study at all, the question got a low correctness rate in both groups. Question D1 had the exact same rate while question D3 had 25 percent more correct answers in group B. Looking at the questions that could be answered in both groups, better results could be observed with group B. Participants who

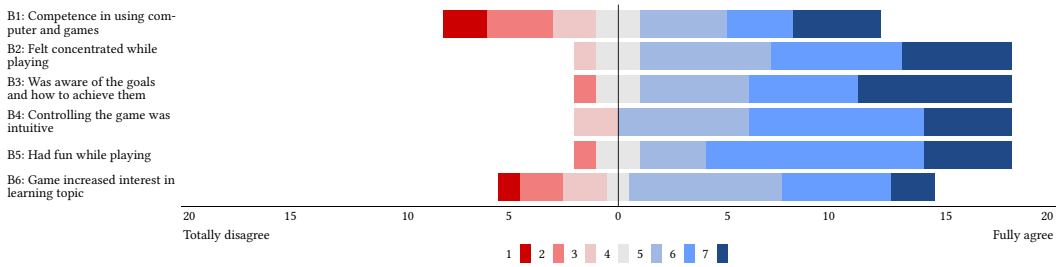


Figure 9.12.: Subjective impressions of group B about game controls, enjoyment and impact. The bars show the distributions of the seven point Likert scale.

played the game had 14.9 percent more correct answers on average than participants who did not play.

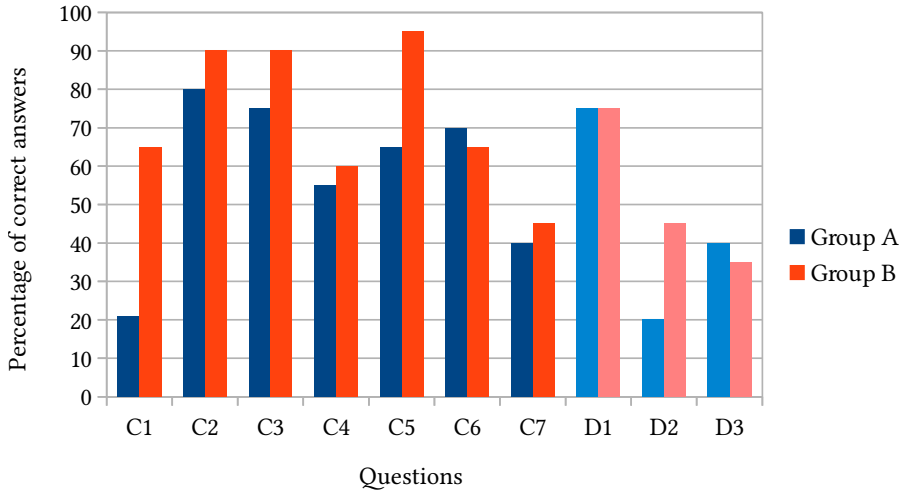


Figure 9.13.: Percentage of correctly answered questions in the test after the processing of learning content in text form (group A) or with text and game (group B). Question D1–D3 are control questions that were not used for the final rating.

The positive results of group B in the test indicate that the game indeed has a beneficial impact on the players' learning performance. However, results of the study did not reveal the origin for the increased performance. A simple explanation would be that participants of group B had a higher motivation of spending time with the learning content in game form than group A which only got the learning content in text form. Participants of group B were indeed motivated to spend that time since they rated the felt enjoyment very high. From this follows that *The Mannheim Game* is able to motivate players to spend time with learning content. Furthermore, the game does not pose a distraction, looking at the increased results in the test. This is an important result since the game was designed to be close to regular entertainment games which could have resulted in a game that is fun but does not have any learning character. The last observation is related to the potential of the game to not only train but to teach, that is, to impart new knowledge and not just

to strengthen existing knowledge. The game supports such mechanisms by providing players with feedback so that they can learn in a trial-and-error fashion, and by letting players help each other with answering questions. Overall, the study strengthened the impressions that were gathered in the various test and demo sessions with the game, and it shows how well entertaining games can be combined with generic learning content.

9.3.5. Discussion

The development of *The Mannheim Game* started with the idea of creating an educational game about the history of the city Mannheim. The city archive Mannheim acted both as external partner and as domain expert for this project. Instead of creating a completely new game from scratch, the previously developed game *Word Domination* was used as basis. It was modified by adding a new game level that features a historical representation of Mannheim's castle as it looked like in the late 18th century. Furthermore, changes to the game mechanics were integrated to embed the game concept into a realistic historical background. The scenario was transferred to a story-based setting where players act as French and German spies that compete against each other to secure plans with valuable data for the upcoming battle.

Results of a comparative user study that was performed in a school examined if and how the game can be used as a valuable learning tool in curricula. Results attested the game positive influences on the learning outcome compared to a non game-based approach. By motivating players to deal with a specific learning content over a longer time span, the game was able to increase the effective learning outcome. Even though the evaluation was performed using *The Mannheim Game*, the results are also relevant for *Word Domination* since both games share most of the game mechanics and learning aspects. The evaluation can be seen as reinforcement of the feedback and the opinions that have been gathered during the various demonstrations of the initial game.

The Mannheim Game is not as generic as its predecessor due to the game contents that were specially crafted for the scenario, that is, the history of the city Mannheim. However, it shows how an existing platform can be extended with some implementation effort while keeping the base structure the same. No implementation effort at all was necessary to integrate new quiz questions into *The Mannheim Game*. Furthermore, all question catalogs are available in both games which is a beneficial feature for the applicability of the game concept.

9.4. Knowledge Defence

The previously presented games in this chapter showed how a fixed game scenario and variable learning content can be successfully combined. While providing such specialized authoring tools that free instructors from hassling with implementation or design details, having a quiz as the only form of learning limits the applicability of the game. The game *Knowledge Defence* that is presented in this section takes up a similar approach. It offers a fixed game scenario that can be filled with arbitrary learning content. Instead of only providing a template for integrating quizzes, however, the game supports adding any

form of learning content through custom-made *learning elements*. This can be done with a web-based framework with which the game client communicates. The approach not only follows the authoring tools' approach of freeing game creators from programming work, but also provides a fixed game scenario so that users do not have to cope with game design details. Instead, users — instructors as well as students — just can add their desired learning content to the system and get a fully functional game as a result. Based on the implemented game, a study was performed that examined the integration of the learning content into the game. Moreover, its purpose was to find out to what degree the learning performance benefits from the combination of game and learning content. Parts of this project have already been published in (Mildner et al., 2014b) and include work done by Eckenweber (2015).

9.4.1. Overview

When creating a game that features dynamic learning content, game designers and developers carefully have to balance the game and learning elements: The game should be enjoyable by players, it should integrate the learning content in a meaningful manner, and it should allow instructors to easily create custom-made game rounds for a variety of scenarios. Combining all these goals into a single product is far from trivial, and compromises have to be found. *Word Domination* proved to work very well in the first category by motivating players to spend time with the game and the learning content. However, by limiting the learning content to simple quizzes, the applicability of the game is somewhat limited. Other forms of learning content — for example, matching a set of terms to different categories — cannot be modeled as quizzes. Additionally, *Word Domination* introduces a break in the game flow by having a fast-paced game on the one side and the reflective quiz handling on the other. Both aspects should be improved in the newly developed game *Knowledge Defence*.

Various games and applications have been presented with relevance to this project. *QuizPACK* is a web-based learning application that uses quizzes to transfer programming knowledge (Brusilovsky and Sosnovsky, 2005). Following a similar idea of using dynamically created quizzes, this application follows a different scope and lacks a dedicated game client. Thus it cannot benefit from the motivational character of entertainment games. A similar approach is followed by Pranantha et al. (2012) who showed how to use HTML5-based games for learning purposes. *The Gopher Game* as well as *WeQuest* combine location-based games with user-generated content (Casey et al., 2007; Macvean et al., 2011). *MobiMissions* is another game that lets players create location-based tasks that other player then have to solve (Grant et al., 2007). This follows the approach used in this work of providing a static game scenario that can be filled with user-generated content at runtime. By relying on location-based game content, however, these games are somehow limited in their applicability for arbitrary learning content.

Full authoring tools like *StoryTec* by Göbel et al. (2008) or *e-Adventure* by Torrente et al. (2008) also allow the creation of custom-made serious games, as further described in Section 6.3. *StoryTec* focuses on 2D graphics with a pre-defined set of game elements that cannot easily be enhanced with other types of knowledge acquisition. *e-Adventure* offers a

simplified graphical editor that allows for the creation of arbitrary adventure games with 3D graphics without the need of actually programming the game. While this gives users a great level of freedom, it is also quite complex to come up with a story, assets and the visual scripting. An application that comes close to the envisioned game is *LearningApps.org*. It allows users to build their own small learning elements in form of pre-defined containers. However, the application is not integrated into an enclosing game, so the focus is more on explicit learning than on providing a full serious game.

9.4.2. Game Design

The design of *Knowledge Defence* had several commonalities with its predecessor *Word Domination*: It should feature the integration of arbitrary learning content into a game that does not require expert knowledge in game development for creating custom game rounds. However, learning content should not be limited to mere quiz questions anymore. Moreover, the integration of the learning content should be done in a way that it does not break the game flow as much. From these requirements, several design decisions followed, both for the game client and the authoring interface.

Game Client

When developing a learning game, the right combination of educational and game elements is crucial. As the new game should support arbitrary user-generated content, a monolithic combination, as done with the game presented in Chapter 8 was not possible. Instead, focus was put on providing one fixed game scenario that can be used with any learning topic.

Knowledge Defence implements the well-known concept of a tower defense game. In this sub-genre of real-time strategy games, it is the players' task to prevent enemy units from crossing a map by placing towers on designated spots. These towers typically vary in their abilities and may shoot the incoming enemy units — also called creeps — or slow them down. Creeps managing to cross the map on a predefined route decrease the player's life bonus. Once the life bonus reaches zero, the player loses the game. Otherwise, if there are no more creeps left and at least one life point remains, the player wins the game and may continue on to the next level.

The game's storyline is based upon an evil-minded antagonist trying to take over the world. In different places over the world, the antagonist launches his units into the map where it is the player's task to defend a research station the enemy units are trying to take over. The setting is in a future version of known locations on Earth.

Integration of Learning Content

As the learning content is user-generated and thus not limited in its topic or type, it cannot be seamlessly integrated into the game environment right away. This again would require expert knowledge on 3D modeling and game design details. Instead, the learning content should be integrated in the form of lightweight web-based mini game elements. Administrative users are able to either use existing elements and fill them with a specific

content or create their own elements for the type of learning content they intend to provide in the game.

The integration of the learning content is done as follows: In tower defense games, the player has an initial amount of some resource, typically money, which is used to build a set of starting towers. For each neutralized creep, the player gains more money. The amount of money earned per enemy unit depends on its strength. The newly earned money may be used to build more towers, or it may be used to upgrade existing towers.

In contrast to regular tower defense games, *knowledge* is introduced as a second resource. This resource is linked to the learning portion of the game. Just as in real life, new knowledge has to be acquired in order to improve existing technologies or to invent new ones. As the secondary knowledge resource is linked to the upgrading process of towers in the game, the game should be designed in a way so that players only can win the game if they actually upgrade the towers during the game. As a consequence, few upgraded towers have to be more powerful than many basic towers. This balancing ensures that players really utilize the learning content rather than only playing the basic tower defense game.

With the initial amount of knowledge, the player is only able to build level 1 towers, that is, no upgrades. As the game progresses and the creeps' hit points increase, it is necessary to upgrade the towers for more firepower. To upgrade a tower and to increase its abilities, a certain knowledge level is necessary. If a player wants to gain more knowledge, he/she selects to play *mini games*. While playing a mini game, the main game is paused. This is so that players have no additional time constraint and can fully concentrate on completing the mini game. By consciously activating them, players also have the freedom to decide whether they want to immerse into the actual tower defense game or to take a break from it in order to gain more knowledge. This approach promises not to disturb the player's flow as much as if the mini games were triggered automatically. A player can play one or more mini games before returning to the tower defense game. The score from the mini games is then added to the player's knowledge level.

As soon as enough knowledge has been collected, the next upgrade level will be unlocked, allowing the player to upgrade towers to the next level. For example, if a player has reached knowledge level 2, he/she may upgrade all towers to level 2 if they have sufficient money to do so. Level 3 towers remain locked until the player acquires enough knowledge to reach knowledge level 3. In contrast to the money resource, the knowledge resource does not decrease when upgrading towers. The knowledge score is saved based on the map and learning content, so players will have to gain new knowledge whenever they play a new level or use a different learning content.

9.4.3. Implementation

Knowledge Defence employs a 3D graphics style to provide the look and feel of state of the art commercial games. Unity was once more used as the underlying game engine. The existing *Tower Defense Toolkit* plugin provided the base functionality that was enhanced by own material, including new models for towers and creeps as well as integrating the knowledge resource. The final game version features five tower types and five creep types.

For each tower, there exist two upgrades which result in a stronger defense against the creeps. Each creep comes in three different versions, each one stronger than the previous. Figure 9.14 gives an overview of different towers and creeps in one of the three levels. The game client is also available for download[7].

Figure 9.14.: Screenshot of the game showing the tower defense principle that is used as basis for the learning game.

For the management of both user data and learning content, a web-based authoring framework was developed. The decision for a web-based back-end was made because it offers a platform-independent way of accessing the data and is also independent of a specific game client. This makes it possible to connect different game clients to access the same learning data. The back-end was built with the *Play Framework*. It is responsible for storing the learning content, offers functionalities to add new content, and can show detailed statistics that can be used to perform learning analytics. In order to manage learning content independent of the game client, it is modeled as web-based elements. In contrast to a native integration like in *Word Domination*, this offers the possibility to add new types of learning content without changing the client. Learning content is implemented as HTML5 pages that are retrieved from the back-end and embedded into the game client (see Fig. 9.15). They are embedded by using the *uWebKit* plugin. By dynamically retrieving learning content from a server, the game requires a constant online connection even though it does not include any multiplayer functions. To circumvent delays by potential connection problems, a caching mechanism has been built into the game client that fetches learning content before it is presented to players. Further details of managing and retrieving the learning content are explained in the following.

[7] `http://www.knowledge-gaming.de/games/knowledge_defence/`

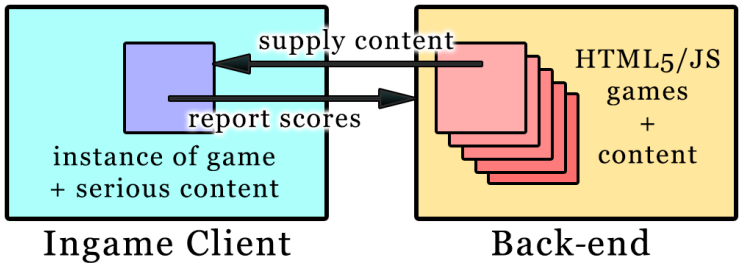


Figure 9.15.: Schematic view of the communication between game client and back-end service.

Data Structure

The back-end uses a relational database (e.g., MySQL) to store all data. Managing user data and statistical data is straight-forward, because both types have a pre-defined structure. Managing the learning content, however, is more complex. As arbitrary types of learning games are supported, there has to be a model that is as generic as possible. A model consisting of three elements, namely *Mini Game*, *Serious Content* and *Learning Container*, has been created (see Fig. 9.16). Along with a suitable data format based on JavaScript Object Notation (JSON), these abstraction layers serve the purposes well, as explained in the following sections.

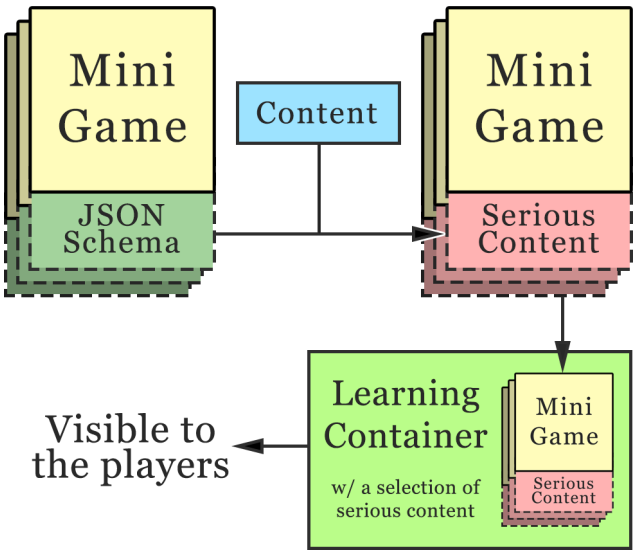


Figure 9.16.: Schematic overview of the data structure used in the back-end service.

Mini Game A mini game defines the basic structure of a type of learning module. This could be a simple quiz, a puzzle, or any other form of learning element. As each mini game can have a different data format, a generic JSON schema was defined. It specifies how

input and output data of a mini game have to look. For example, Listing 9.1 shows the schema of a simple Hit the Buzzword (HTB) game. A phrase is given for which the player should think of descriptive words. Up to four unique buzzwords can be saved that are a valid solution. The game logic then only has to check whether an entered word matches a word in the `htbgame.buzzwords` array.

Listing 9.1: Exemplary JSON schema for a simple "Hit the Buzzword" game.

```
"htbgame": {
   "type": "object",
   "properties": {
      "phrase": {
         "title": "Phrase",
         "type": "string"},
      "buzzwords": {
         "type": "array",
         "items": {
            "title": "Winning buzzwords",
            "type": "string"},
         "minItems": 1,
         "maxItems": 4,
         "uniqueItems": true}}}
```

This schema builds the foundation for the next step. The uploader/creator of a mini game has to specify a JSON schema for it so that the back-end is able to serve the mini game with a valid JSON data structure to fill it with actual content. Along with the schema, a score rule has to be added as well. It determines how results from the mini game should be interpreted. For example, in the HTB game a player could get more points for guessing one of the correct words with fewer attempts. The score rule ensures a fair score distribution between different types of mini games.

Serious Content While the previously described JSON schema only defines the data structure of a mini game, *Serious Content* defines the actual data that is linked to a type of mini game. Together with an HTML5/JavaScript based element they form a complete learning unit a player can use. Following the previously used HTB game, an example of serious content could be the phrase *"A member of The Beatles"* in conjunction with the buzzwords *{"John Lennon", "Paul McCartney", "George Harrison", "Ringo Starr"}*.

In order to serve serious content to a player properly, a valid JSON data structure according to the underlying schema has to exist. Before the JSON data structure is actually inserted into the database, it is therefore validated against the JSON schema defined in the *Mini Game*. Obviously, entering this data as a manual JSON structure is not feasible. Therefore, the *JSON Form* library[8] for generating HTML form elements was used. The administrative users who are responsible for maintaining serious content do not need to

[8] `https://github.com/kimsey0/jsonform`

know the raw JSON structure. Instead, data can conveniently be entered by filling out the generated HTML form.

Learning Container Having defined data structure and learning content, the only remaining task is to group the mini games filled with serious content. This is done in a *Learning Container*. It represents an ordered set of playable mini games. Each set can contain an arbitrary number of elements which in turn can be part of multiple containers. Continuing with the example, a container "Music History" could contain the previously mentioned HTB game about The Beatles and another HTB game about The Rolling Stones. When players start a game round, they can choose one learning container to use in the game. During the game, its elements will then be iteratively served to the game client.

Adding New Content

Adding new content to the back-end is split into two parts. Creating a new dataset for an existing mini game is trivial, as a user just has to enter the data into the provided HTML form. The data is then transformed to the respective JSON structure which is made available to be added to learning containers.

The initial version of the game features six different types of minigames: quiz, cloze text, memory, grouping terms, matching/non-matching terms and creating sequences. A selection of them is shown in Fig. 9.17.

Adding a whole new mini game to the back-end requires more effort. Along with the required JSON schema, the actual HTML content and further assets (css, images, sounds, etc.) have be provided as well. This includes the logic of a game as well as its design and appearance. As each game can have completely different looks or mechanics, this process cannot be automated. Once created, a newly created mini game can be uploaded as a zip file. The archive has to contain everything the mini game needs to run, like the JSON schema and all the assets. After uploading the game, it gets unzipped into a randomly generated directory on the server. A small web server was therefore integrated into the *Play Framework* itself, called *MiniGameDeployer*. On the one hand, it handles all incoming HTTP requests concerning the mini games — like delivering assets. On the other hand, it is responsible for injecting the serious content that is stored in the database into the header of the mini game. The mini game can then be accessed by the game client.

9.4.4. Evaluation

Based on the implemented prototype, an evaluation was performed to answer the question to what degree *Knowledge Defence* helps to promote learning. Before performing the evaluation, a second game called *Minigame Challenge* was implemented. It uses the same learning content as *Knowledge Defence*, but it lacks the explicit game character. The game comprises solely the mini games themselves presented on a web site, enhanced by highscores and achievements. Players simply select a learning container and then either play all mini games in a row or in a time trial mode. By omitting a dedicated game

(a) Cloze Text (b) Memory

(c) Quiz (d) Grouping

Figure 9.17.: A selection of the available mini games. More games can be dynamically added through the web interface.

client, *Minigame Challenge* has more the features of a learning application than of a game. Consequently, it acts as a base line to which *Knowledge Defence* can be compared.

Based on the two variants, a user study with 15 participants (9 male, 6 female) was performed. Eleven participants were between 20 and 30 years old, forming the largest age group. In general, most users indicated a high affinity to using computers, but almost none of them were frequent gamers. 80 percent stated that they play rarely or not at all. Then again, 8 participants already played a learning game at least once. The evaluation consisted of playing both game variants, each with a learning container with common knowledge content. Both the order of games and the selection of learning containers were randomized. After the two game sessions, participants were asked to fill in a questionnaire. The duration of each evaluation session was 30–45 minutes.

The focus of the questionnaire was on the comparison of both game modes. Questions from group A contained generic questions about the games whereas questions from group B were related to the perceived learning effectiveness. In the following, comparative

values will be in order of how they are illustrated in Figs. 9.18 and 9.19, that is, *Knowledge Defence* before *Minigame Challenge*.

Looking at the generic questions, results were mixed (see Fig. 9.18). The perceived fun level (question A1) is on a similar level. This was unexpected since *Knowledge Defence* offers a whole gaming experience while the other variant does not. This circumstance can be explained by the fact that a part of the participants were not used to playing games and thus were more satisfied with the smaller scope of *Minigame Challenge*. When only taking users into account that use computers regularly, both variants have the same mean value of 3.63. A similar trend can be seen with the rating of the basic game idea (question A2) with mean values of 3.73 and 4.13, respectively. Surprisingly, game graphics (question A3) received nearly the same average ratings of 2.6 and 2.67, but results for *Knowledge Defence* show a high standard deviation of 1.35. This reflects the heterogeneity of the participants' attitude towards games once more. Question A4 that referred to the controls showed better results for *Minigame Challenge*. A reason for this might be that it has a much smaller scope than its rather complex game counterpart *Knowledge Defence*.

Results from the questions regarding the perceived learning effect showed a clear tendency towards *Minigame Challenge* (see Fig. 9.19). Participants rated questions B1–B4 very positively for this game variant with mean values of 2.2–2.4 versus 4.0–4.1. This trend is further confirmed by the direct question which application was better suited for learning: 14 out of the 15 participants voted for *Minigame Challenge*. An explanation for such clear results can be given by the intention of the participants: Since they were aware of the fact that they were using a learning application, the gaming parts of *Knowledge Defence* only posed a distraction from the pure learning content.

9.4.5. Discussion

This project started as an experiment how to combine a fixed game scenario not only with arbitrary learning content but also different forms of learning content. The basic design was derived from the previous project *Word Domination* where a similar approach already proved to be effective (see Section 9.2). In contrast to this game, however, *Knowledge Defence* went one step further: Learning content was not integrated natively but as web-based mini games. This approach allows to modify the learning content or to add new types of mini games without changing the game client at all. At the same time, the game was designed to integrate learning and game parts more tightly. First, the acquisition of knowledge is woven into a story-based approach. Players have to solve mini games in order to increase their knowledge levels which in turn enables them to research more powerful tower upgrades. As such, learning content is not just plugged onto the game, but it is an essential part of it. Second, emphasis was put on not breaking the game flow when solving the educational mini games. Since the game only employs a single-player mode, the pace of the game can be changed at any time, and players can freely decide when to solve mini games and when to play the tower defense mode.

The included authoring tool allows for the integration of new forms of knowledge acquisition. This was achieved by combining a static game scenario with lightweight, HTML5-based mini games that contain the learning parts. Learning content can be added

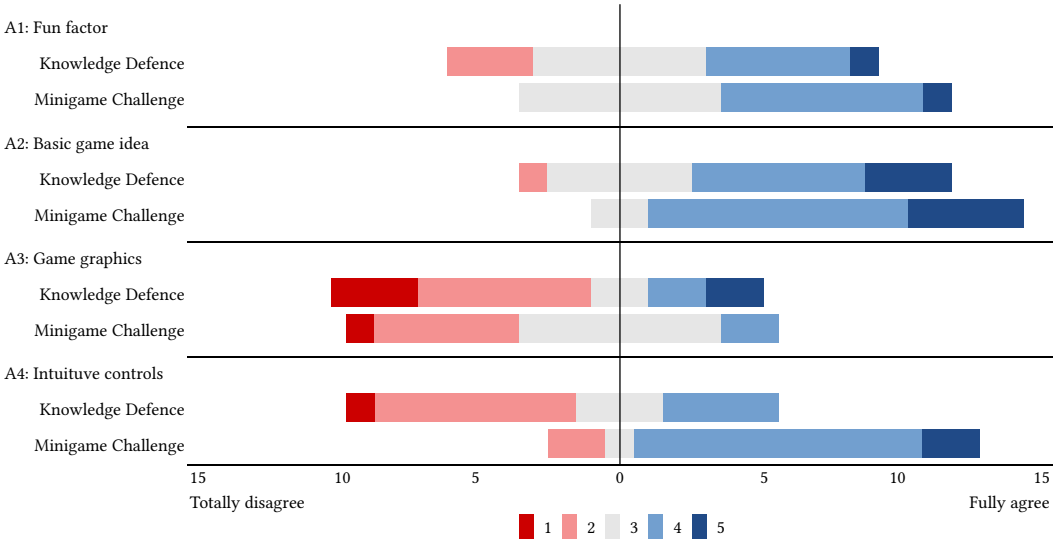


Figure 9.18.: Evaluation results showing the questions about the general game characteristics. The bars show the distributions of the five point Likert scale.

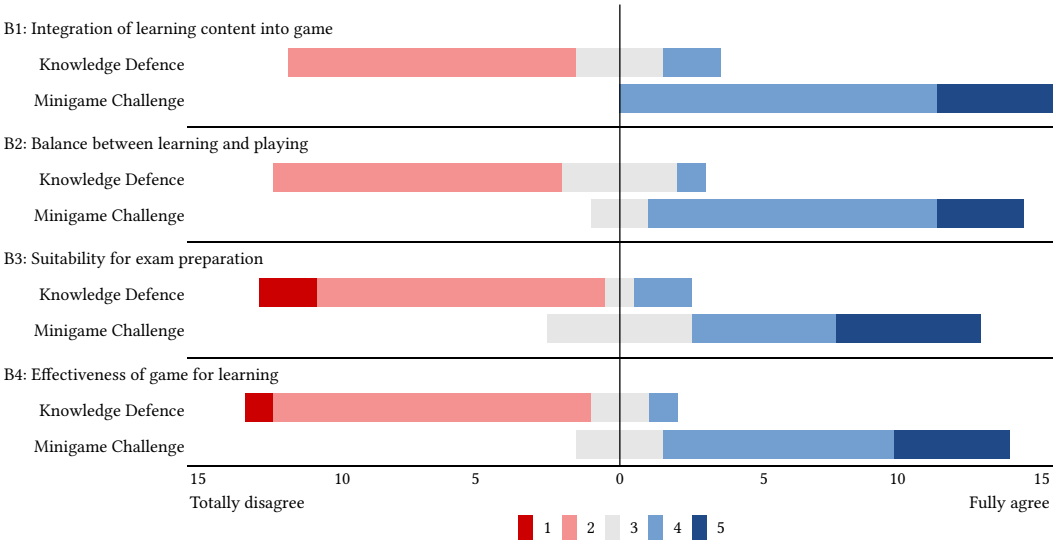


Figure 9.19.: Evaluation results showing the questions about the learning aspects of *Knowledge Defence* and *Minigame Challenge*. The bars show the distributions of the five point Likert scale.

in a web-based authoring tool in HTML forms that are created dynamically based on the type of underlying learning element. If users want to create a new game round, they may just use the existing mini games and fill them with their specific learning content. This process is simple, does not require any game development knowledge, and it is much faster than implementing a new custom game from scratch: While developing the prototype along with the back-end took about 3.000 person-hours and one year of work, adding new content can easily be done in less than an hour.

In addition to using the predefined set of mini games, the game also allows for the creation of new mini games with custom functionality. This requires specifying a JSON schema so that the authoring interface can interpret the data format of the mini game. As shown in Listing 9.1, a schema for a new game can be created relatively easily. In addition to that, basic HTML and JavaScript knowledge is necessary to implement the functionality of the mini game. This results in more work for the developer of new mini games than for users who just use existing mini games. However, the creation process itself can be quite fast, as the game client and the mechanics do not have to be changed.

A comparative users study that was performed based on *Knowledge Defence* and a web-based alternative that only consisted of the mini games themselves (*Minigame Challenge*) produced interesting results. Participants rated both variants mostly similar when looking at the basic elements such as perceived fun and controls. The perceived learning effects, however, were much better rated for *Minigame Challenge*. This is understandable since this tool is more effective when it comes to delivering pure learning content in a given amount of time. The fact that participants did not rate the fun level of the game higher indicates that they had a high intrinsic motivation towards learning. *Knowledge Defence*, on the other hand, is primarily geared towards users who either seek for an extrinsic motivation or just want to take a break from regular learning sessions. This again illustrates the important factor of matching the target group and the game, as already discussed in Section 5.4. Moreover, it shows that learning games — even if designed well — do not address all kind of learners. They provide a useful tool in many application scenarios, but they should not be seen as the best approach in every situation.

9.5. Summary

After studying the effects of serious games with static serious content in Chapter 8, this chapter examined games with dynamic serious content. Four games were created that focused on different aspects of providing dynamic learning content in serious games. First, the game *LibChase* was created for teaching students how to use the various library services. To give the library staff a high degree of freedom for creating and maintaining the game content, a simple gamification-based game concept was combined with an authoring interface that allows to edit the whole game. As seen with the static serious games, a close cooperation with the domain experts proved to be an effective measure to optimize the final game. Second, *Word Domination* put the focus on creating educational games that draw from the motivational factors pure entertainment games provide while working with generic learning content. The combination of a FPS multiplayer game and quizzes that

can conveniently be maintained in a web-based authoring tool was successfully tested in a user study and various public demonstrations. Third, the positive reception of *Word Domination* was used to create another game that shares the basic game concept. *The Mannheim Game* transfers the generic approach of its predecessor to a more specialized setting. It features content that is linked to the history of the city Mannheim to teach this topic to students from middle and high school. A comparative user study where the game was tested against non-gaming-based teaching material showed the effectiveness of the game and the underlying concept. Last, *Knowledge Defence* again continued the game concept of *Word Domination*, but the game was designed to integrate more diverse learning content than quizzes. Like the learning content itself, new types of learning content can be dynamically added to the game.

The games presented in this chapter relate to the second main research question of this thesis, namely how generic serious games can by created that are both fun and effective in delivering the serious content. All games feature some kind of authoring tool that allows to edit the learning content. The approach used here was to minimize the required expertise on game development for the domain experts. Instead, it should be able to edit the learning content without having to alter the game parts at all. The game scenarios and the corresponding game mechanics were therefore fixed with all the games. This approach proved to be effective in delivering learning games that are both fun and effective, as various demonstrations and user studies revealed. However, up to this point it is unclear to what degree these dynamic serious games are better or worse than games with static content. This aspect will be examined in the next chapter.

10. Effects of Game World Coherence on Game Effectiveness

Chapters 8 and 9 presented a set of serious games with both static and dynamic serious content. Games of the former type provide the highest degree of freedom in the game creation process since they can be specifically tailored towards a certain scenario. However, such games require considerable development effort and expertise as seen with *Corruptica*, for example (see Section 8.2). Games that feature dynamic serious content, on the other hand, allow non-professional game creators to include custom serious content without having to know development details. This increases the re-usability of games or frameworks and enables to use game-based learning even with limited resources.

As presented in Chapter 6, specialized authoring tools offer the easiest way to include custom serious content. An inherent characteristic of these tools is the decoupling of learning and game content since they provide a fixed game scenario that can be combined with arbitrary learning content. The games presented in Chapter 9 and especially *Word Domination* showed that this approach is effective in motivating players to spend time with the learning content and thus to increase the learning outcome (see Section 9.2.4). However, the question if or how much a coherent game world, that is, matching game and learning contents, would have influenced the results remains open. Specifically, the following research question is of interest:

> *To what degree does a matching scenario between game and learning content influence fun and learning outcome in comparison to a decoupled scenario where game parts and learning content do not share a common theme?*

To get insights on the formulated question, an experiment was conducted. *Word Domination* was used for this purpose since it already proved to be effective on its own. Based on the original game, an alternative level and game mode were implemented, and fitting learning content was created. Both game variants were then evaluated in a school with high school students. The details of the evaluation are presented in the following. It includes work done by Reinsch (2015).

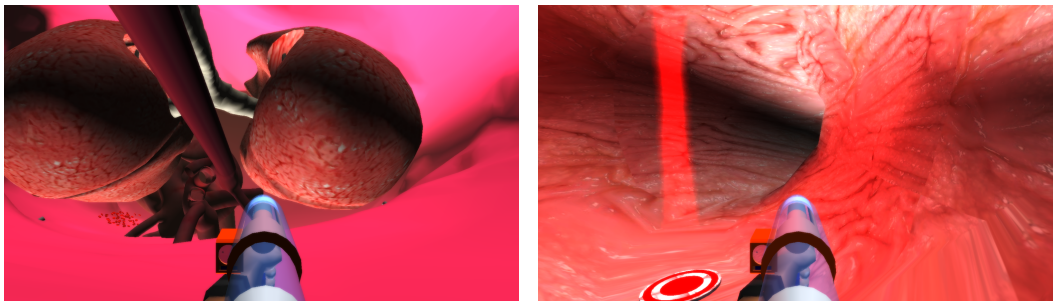
10.1. Adapted Game Variant

Originally, *Word Domination* just came with one generic game level. It is a FPS game, and it features an arbitrary landscape with vegetation and some details such as a lake and big rocks. This generic level design was used intentionally because it is fun to play, and it provides a basis for different learning contents. Consequently, a more detailed level or one that has a specific theme would have posed a distraction from the actual learning content.

Since just this aspect should be evaluated in the new study, a new game level had to be created that was related to a specific learning content.

An option would have been to use the Mannheim level that was later added to the game. Since this game adaption was not finished at the time of this study, however, this was not possible. Moreover, it was desirable to have a topic that is also taught in high schools to have a specific relation to curricula. For that reason, a third level was added to the game.

The learning content for the study was set to the topic of biology. Specifically, the questions were all related to the functioning of the human body. The topic was picked because it is taught in high school, and it is well suited for being visually represented. This has also been done in *Re-Mission* where players travel through the human body to fight against cancer. A similar setup was chosen for the adapted *Word Domination* level. The level features a representation of the human body where players can travel to different inner organs with their avatars. In total, there are four organs included: brain, heart, lungs and stomach. The level was not modeled completely realistically to allow for some artistic freedom in the level design. For example, there is free space for the players to move around, and the organs are not connected to the circulatory system. However, the positions and proportions of them are mostly correct. Figure 10.1 shows impressions from the modeled level.



(a) Exterior view of lungs and heart

(b) Inside the stomach at a captured platform

Figure 10.1.: Screenshots of the adapted *Word Domination* level with content about biology.

Other than the new level, the game mechanics from the original game largely stayed the same. There are still two teams of players that have to fight over the prevalence of the map by conquering platforms that are spread over the map. These are hidden within the different organs. Consequently, players will have to explore the human body and get familiar with the different positions and properties of the organs. The only addition to the game mechanics is a so-called *Highlight Mode*. When enabled, random platforms get highlighted for a certain time span. When a new platform gets highlighted, players get a textual message with the name of the platform, and the platform gets lit in green. If it is conquered while being highlighted, the respective player/team will get a score bonus. This action is possible for both teams even when the platform is already conquered by one team. Two reasons led to this new game mechanic. First, it promotes players to gather at

certain areas of the map, allowing for more interactivity and battles which in turn results in more questions being answered by players. Second, it includes a learning effect on its own since players have to find the correct organ in the body based on its name.

Before the actual user study started, several user tests were done with prototypes of the game. They revealed minor shortcomings of the level that were fixed. For example, the distance between the different organs were felt as too long. Consequently, teleporters were added to distinct positions in the level, allowing players to quickly travel between different places. Since some testers remarked that it was difficult to find the platforms within the organs at the beginning, animated blood cells were added that lead players to the platforms. In preparation for the evaluation, the new game mode with highlighted platforms was also added to the original level. In this way, players can play the exact same game mode just with different levels.

10.2. Study

The study was conducted in a high school in Weinheim, Germany. 23 students (18 male, 5 female) with an average age of 11.7 years participated. Regarding demographic factors and background knowledge, this group was a representative sample: Most participants stated to play video games 2–6 hours per week, and 70 percent of the students already dealt with the learning content in their curricula. *Word Domination* could therefore mainly be used as a training tool to memorize the already acquired knowledge.

Based on the central research question formulated earlier, the following hypotheses were used for interpreting the results: A better game world coherence — that is, having matching game and learning content — leads to an increased interest of players. This leads to a higher arousal level which in turn results in a better flow experience. When players are within the flow zone, they will be more satisfied with the game. Finally, this will lead to a higher learning effect as players enjoy the game and tend to spend more time with it.

Two groups were formed. Group A (11 participants) got to play the original, non-adapted version of the game. The 12 participants of group B played the adapted version with the level related to biology instead. The learning content was the same for both groups, namely questions about the human body. After an introduction to the game and its controls, students played two game rounds. Each round lasted for five minutes. After the game session, participants were asked to fill in a questionnaire. It consisted of nine question groups that related to the categories of the perceived interest of participants, the flow experience, the perceived learning effect and general questions. Interest of players was further divided into situational and individual parts (Chen and Darst, 2002; Linnenbrink-Garcia et al., 2010). The full set of questions is shown in Table A.1 in the Appendix.

Looking at the results of the questionnaire, general questions were rated similarly by both groups (see Fig. A.9). This indicates that both levels are comparable regarding the pure game parts. Further results are therefore not dependent on factors such as players of both groups performing differently because they are not able to control the game correctly. Figure 10.2 gives an overview of the collected answers. Regarding the perceived interest

of players, participants of group B showed higher results. For example, players were more engaged by answering the questions (question SI2) and stated that they would like to know more about the learning topic (question SI9). Similar increases can be seen with questions regarding arousal, flow and finally the perceived learning effect. Players of group B felt more immersed into the game (question FI2) and had more fun while playing (question FE1). They also showed a higher general satisfaction with the game (question S1). Finally, players of the adapted game level had the impression of learning more from the game than the other group (question L1).

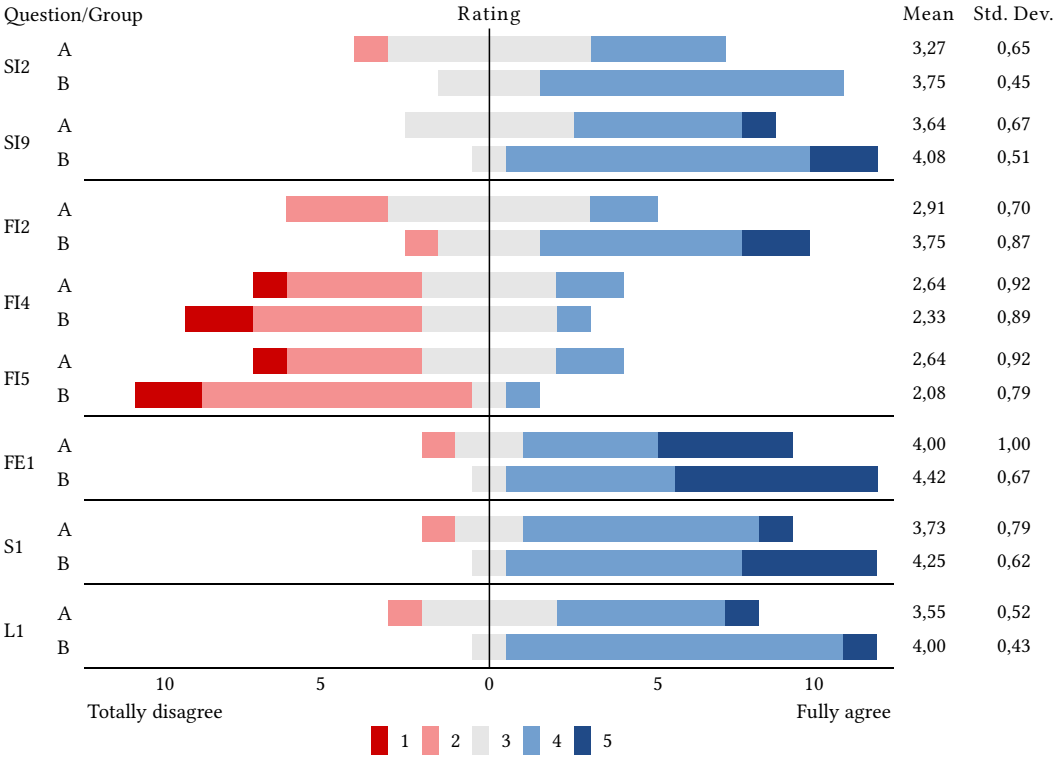


Figure 10.2.: Selected results from the study on the influence of game world coherence. The bars show the distributions of the five point Likert scale. All individual results can be examined in Figs. A.1 to A.9 in the Appendix.

Summarizing the results from the study, it can be concluded that playing a game where learning content and game world match results in an increased learning effect. It should be noted that *Word Domination* — both the original and adapted version — is still an extrinsic game. In contrast to intrinsic games, the game mechanics itself are not coupled to the learning content, as discussed in Section 5.4. It follows that the increase of effectiveness is only related to the representation of the game world and not the game mechanics. Using an intrinsic game — potentially with static learning content — might result in an even higher increase in learning effectiveness, as argued by Habgood and Ainsworth (2011). However, the study also revealed further insights into the effectiveness of *Word Domination* as a whole. Looking at question FI4, players only saw a little distraction or none at all in

answering questions during the game. Similar answers were given for question FI5 that related to the distraction that the game poses when dealing with the learning content, that is, answering questions. For a purely extrinsic game, these are positive results showing that combining an engaging action game with generic quizzes actually works well.

10.3. Discussion

This study was performed to find out to what degree a coherent game world where game content and learning topic share a common scheme influences the learning outcome in contrast to a game with no such coupling. Results from the evaluation that used two versions of the game *Word Domination* confirmed the hypothesis, showing that matching contents indeed result in a better learning effect. However, the increase is not as high as initially expected. Looking at the questions regarding the perceived learning effect, both groups generally agreed that the respective game variant is an effective learning tool (see Fig. A.8). Results from players of the adapted game version were about half a point higher on the five point Likert scale. The question remaining open for discussion is whether *the slight increase in effectiveness justifies the amount of work for creating an adapted game version.* After all, this task requires knowledge in game design, graphics modeling and programming, just like creating a new game.

The following recommendation can be given, based on experiences gathered throughout this thesis: An adapted scenario should be chosen if development resources allow it or professional game developers are at hand. This approach yields the highest potential for creating an effective learning game. Whether only the game world should be modeled coherently to the learning content or a completely new game should be created — potentially with static learning content that allows an even tighter integration — depends on the available resources and the intended usage scenario. If, however, these resources are not available, for example when a teacher wants to introduce game-based approaches into the curriculum, generic games that allow for the integration of custom learning content such as *Word Domination* pose a viable alternative. Since new game rounds can be created only by providing new learning content, this process comes with almost no costs, and experiences with such games showed that the increased engagement of players leads to a measurable learning effect.

When working with a generic game approach, there again is not just one option. Instead of choosing between a completely static game (e.g., *Corruptica*) and a dynamic game where only the learning content has to be changed (e.g., *Word Domination*), a third option is available. Such an alternative was presented with *Knowledge Defence*: The game provides a static game scenario that can be filled with arbitrary learning content. However, not only the subject of the learning content is dynamic but also the type of it. The framework allows to add new minigames, that is, new forms of learning material, into the existing game. In contrast to just entering learning content this requires some implementation effort, but compared to creating a new game from scratch the effort is much smaller. Creators of such minigames can focus on a small isolated piece without having to cope with the design and the development of an entire game.

11. Conclusion

The central research question of this thesis was how serious content and game elements have to be combined to create serious games that are fun and effective in transporting the serious content. Along with presenting theoretical background, seven games were developed within the scope of this thesis. They can be split into two categories: games with static content and games that feature dynamic serious content. The former type depicts the more traditional approach of game creation. Here, a game is created by professional game developers with a specific setting and content in mind. Once it is finished, it is released and not changed anymore. A prototypical example for such games is *Professor Architecto's Quest*. It is a learning game about architecture for younger students that features story-driven content in the style of well-known adventure games. The contained learning content follows a stealth learning approach that is intended to raise interest in the topic. The game was designed to be played in educational contexts where a supervisor oversees the game and leads subsequent discussions. Despite being a static game, the level layout was designed in a manner that makes it easy for developers to add new content without changing the rest of the game. This feature increases the potential usage of the game since new aspects can be added without creating a new game from scratch.

In terms of intended usage, *Corruptica* resembles the previous game. Once again, the game features learning content that should foster interest and discussions among players and supervisors. In terms of learning content and target group the games differ in that *Corruptica* was designed to deliver aspects of business ethics to university students. Looking at the complexity of the implemented game mechanics, this project was the most sophisticated of all the seven games. It features common mechanics from construction and management simulations that were enhanced with ethical aspects. The game was evaluated by students in a lecture on business ethics. Overall, the results were very positive. Players enjoyed the game and were pleased with the general usability of the game. This was remarkable since the majority of players were not used to this game genre or games in general. The motivational factors were further confirmed by the fact that a part of the students kept playing the game in their leisure time. The implementation of the ethical aspects got mixed results. While some participants stated that they actually could empathize with the challenges the stakeholders have to face in the game, others did not consider the game relevant for their education. This was probably due to the character of the game that fosters critical thinking but does not directly prepare for an upcoming exam. Then again, addressing all kinds of learners in a single game is near to impossible. Some appreciate the additional elements games offer while others see them as a distraction from the pure learning content.

Another important factor in the game creation process was examined with the example of a training game for alcohol-addicted patients, that is, picking the right scope for a project.

The initial game idea included a realistic virtual world with 3D graphics in which players can freely move and interact. Since the game should be used in training with a need for repeatable game play, this approach would have cost much more resources than were available for a first version. As a consequence, a more static approach was chosen were images that were taken in real-world locations were used instead. A realistic environment was therefore given a priori, and only the freedom in movement and interactions was limited to predefined actions that resembled the mechanics of point-and-click adventures. A preliminary study revealed that patients actually perceived the modeled situations as realistic. The smaller scope chosen therefore lead to a functioning game while the initial idea could not have produced any usable results in the same time.

Summarizing the results from the games that were created with the normal approach of using static serious content, the following conclusions can be drawn: A lot of manual work is necessary for each new project. Suitable game mechanics have to be defined for the serious content and the intended target group while coping with limited budgets or development resources. This makes it difficult to come up with generally applicable techniques how to create the perfect serious game. What can be done and improved, however, is to bring the different stakeholders in serious game development closer together. An important aspect of this proposition is the game design phase. Here, the right decisions have to be made before the actual game implementation starts. While a lot of techniques can be borrowed from designing pure entertainment games, special emphasis should be put on integrating the serious content in a meaningful manner. A contribution to tackling this challenge has been given in Part II with assembling hints and considerations for the creation of serious games and with the experiments conducted with the aforementioned games. One of the most important challenges is to consider the creation of serious games as a holistic approach: Neither should serious content just be plugged onto any existing game concept without considering the special characteristics of both, nor should game parts be used as a mere motivation to make an otherwise boring task fun. It is also important to specify the requirements and intended usage of serious games as precisely as possible right at the beginning of the creation phase. Moreover, the different stakeholders, including designers, domain experts and users, should constantly communicate to produce a game that matches everyone's expectations.

The second set of games that were developed within the scope of this thesis employs dynamic learning content. In contrast to static variants, these games allow the manipulation of learning content through an authoring interface. The general idea of authoring tools is to make the creation of serious games more accessible to non-professional developers such as teachers. Just like manually created games, these tools also have to cope with the challenge how to combine learning and gaming content. The majority of them frees game creators from implementation work but does not provide much assistance with game design and the integration parts. The games presented in this thesis differ in that they provide predefined game scenarios. This approach promised good results since the game scenario can be manually crafted by professional game developers whereas domain experts only have to enter the pure learning content, making such specialized authoring tools highly accessible. The related research question was whether these dynamic games can compete with static games when it comes to effectiveness and motivational factors.

A collaboration with the university library Mannheim resulted in the learning game *LibChase* about getting to know the various services of the library. The game was modeled as a treasure hunt with a mix of location-based tasks (e.g., locating the different locations of the library) and normal tasks (e.g., quizzes, learning how to use the online catalog). Due to the strong relation to the real world, the game does not include any fantasy elements. Instead, it comprises of a series of tasks which players have to solve in order to be rewarded with experience points or achievements. Such elements are also often included in gamification applications, and the game indeed resembles them. Special emphasis was put on the easy adaptability of the game. To allow administrative users to adapt the content, an authoring tool was integrated into the game. It supports the complete editing of the game content and is only limited by the predefined set of task types. As a result, the game can easily be used by other libraries or even other institutions since the given task types can be used for a wide range of application scenarios. Even though the game does not employ complex game mechanics, it approached the research question by providing reusable game elements, minimizing the effort for creating such a game.

The multiplayer learning game *Word Domination* acted as a central object of study in this thesis. By providing a fixed game scenario that can be filled with arbitrary learning content, it depicts a prototypical example of games with dynamic serious content. The main motivation for its creation was to utilize the motivational aspects of common entertainment games for learning purposes. To approach a broad audience, the genre was set to a multiplayer FPS game since it is one of the most played genres. Simple multiple choice quizzes were chosen as the learning content. They are easy to create and provide a generic way to model any topics of interest. The game mode is both competitive and cooperative: Two teams of players are competing for the prevalence over a virtual map. Players of the opposing team can be hindered by hitting them with thrown objects such as balls — other than that the game does not employ any offensive or even violent action. The players then have to answer a question before they can proceed with the game. The questions can be maintained in a web-based authoring tool that also contains analytics parts.

Based on the original version, two variants of *Word Domination* have been developed. *The Mannheim Game* included modifications in both the game level and the game mechanics by transferring the game into a historical setting. It is meant to teach the history of the city Mannheim to the players. A third game variant only provides a new game level that is set inside the human body.

Word Domination was presented at various public demonstrations. Furthermore, the three game variants were evaluated by three user studies that covered different aspects of the game. Overall, the game concept received positive feedback regarding the motivational aspects. While it mainly addressed the prototypical player types, namely young male players, the game was played by a diverse audience. Participants of the studies undermined the impressions gathered at public demonstrations by stating that the game was fun to play and easy to use. The achieved learning effect was also measurable in a comparative study in which *The Mannheim Game* was tested against regular learning material. It has to be noted, however, that the kind of learning effect is different from the static games discussed above. Since *Word Domination* and its variants do not have a strong connection

between learning content and game scenario, an increased learning outcome is mainly attributable to the fact that players enjoyed the game itself and thus spent more time with the learning content. The act of answering questions during the game did not pose a big distraction even though it tends to disrupt the game flow, as criticized by some players. In sum, combining the easy-to-use authoring tool with an engaging game scenario proved to be an effective way to include arbitrary learning content into a game-based environment.

Based on the concept of *Word Domination*, another game with dynamic learning content was created. *Knowledge Defence* follows the same approach of having a predefined game scenario — in this case a tower defense game — that is enhanced with dynamic learning content. In contrast to the previous game, not only quizzes were allowed as type of learning content, but the game supports custom-made learning elements. They are dynamically integrated as web-based mini games. A study that compared the game against the pure learning content (i.e., the web-based mini games) showed that most participants preferred having only the latter since it was more effective. This shows again how important it is to keep the context in mind in which a learning game is used: In situations where learners have an intrinsic motivation, an extrinsic game only poses a distraction. This can also be seen as a limitation of generic games where learning content and game are not related. Such games cannot have such a tight integration of both parts so that the game itself depicts the learning content. Instead, extrinsic games can only utilize the motivational aspects of games in general. If users are not interested in that, working with the pure learning content is obviously the more effective approach.

Looking back at the insights that could be gathered by creating different learning games with dynamic content, the following conclusions can be drawn: Especially the game *Word Domination* showed that it is indeed possible to create effective learning games that support arbitrary learning content. The combination of game mechanics that are commonly used in entertainment games with an easy-to-use authoring tool proved to be effective in terms of creating motivation and actual learning outcome. However, it was of interest how such generic games perform in comparison to games where game and learning contents match. A study about this game world coherence was therefore conducted. It worked with *Word Domination* in the original version and one that used a new level that corresponded to the employed learning content, the human body. An evaluation in a school revealed that motivation and perceived learning effect was higher with the adapted version of the game. Then again, the unadapted version only scored slightly worse. The short answer to the question thus is that adapted games generally work better than generic ones. Taking into account the effort it takes to create a game, however, the answer is not so clear anymore. Developers have to weigh if it is worth spending a considerable amount of development effort for a slight increase in effectiveness. In the end, coming up with a generally applicable solution is not possible due to the diversity of this field. The presented tools and considerations in this thesis should nonetheless assist game developers and domain experts in creating more effective gameful learning environments.

Outlook

Producing static serious games that feature a tight coupling of serious content and game parts — potentially employing an intrinsic gameplay — will stay a manual approach for the time being. This thesis presented practical tips and hints how the creation process can be optimized, but the effort for creating such games still remains high. However, given that sufficient resources and professional expertise is available, static games promise high impacts in terms of effectiveness, rectifying the costs.

Since too often there are too few resources available for turning a specific learning content into a game-based application, more work should be done for increasing the accessibility of game creation tools. Regular authoring tools are available, allowing non-professional game developers to create custom games. However, tools that do not require any knowledge in game development and game design still need work. Refining such tools would allow more domain experts to create effective serious games in less time. Work could be done by supporting more forms of learning contents other than simple quizzes, as seen in *Word Domination*.

Another interesting aspect would be to create game scenarios that address a broader audience other than regular gamers. This task is not trivial since extrinsic games draw their main motivational factors from the pure game parts. Consequently, players have to be appealed by the game itself in order to achieve a learning effect with it. Moreover, increasing the coupling of learning content and game parts in games with dynamic serious content would be beneficial for increasing the effectiveness of them. For example, it would be interesting to develop a game scenario that could adapt to different forms of learning content. A game could change its pace depending on whether the current learning content requires reflective or fast thinking. Generally, employing more automated mechanisms would help to create better integrated games. A related aspect that received only little attention in this thesis is the automatic adaption of the game to the players' skill levels. Integrating improved mechanisms into serious games — including static and dynamic variants — helps players to stay in the flow zone and to keep engagement on a high level.

Providing teachers or instructors with more accessible tools to turn learning content into games certainly is a good way to improve the usage of serious games. However, apart from improving the creation process and the effectiveness of serious games, the general use of them should still be further promoted. This does not mean that games should replace existing approaches that proved to work well. Serious games should better be seen as another tool that can be used to reach more types of learners or to offer an alternative to regular teaching methods. Giving users the freedom to choose the method that suits them best allows for more individual and ultimately for better learning experiences.

A. Evaluation Results

A.1. Corruptica

Results

Survey 351448

Number of records in this query:	22
Total records in survey:	22
Percentage of total:	100.00%

Field summary for X1

Haben Sie bereits eine oder mehrere Spielrunden von Corruptica gespielt?

Answer	Count	Percentage
Yes (Y)	19	86.36%
No (N)	3	13.64%
No answer	0	0.00%

Field summary for X2

In welcher Umgebung haben Sie Corruptica gespielt?

Answer	Count	Percentage
Vorlesung (SQ001)	12	63.16%
Freizeit (SQ002)	8	42.11%
Other	1	5.26%

ID	Response
16	beides

Field summary for X3

Wie oft haben Sie Corruptica bisher gespielt?

Answer	Count	Percentage
Einmal (A1)	12	63.16%
Zwei- bis dreimal (A2)	7	36.84%
Other	0	0.00%
No answer	0	0.00%

ID	Response

Field summary for X4

Auf welcher Plattform haben Sie Corruptica gespielt?

Answer	Count	Percentage
Windows (SQ001)	15	78.95%
Mac OS X (SQ002)	4	21.05%
Linux (SQ003)	0	0.00%
Webbrowser (SQ004)	0	0.00%

Field summary for A6(SQ001)

Bitte bewerten Sie die folgenden Aussagen auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Das Spiel hat mir Spaß gemacht.]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	4.55%
2 (2)	1	4.55%	
3 (3)	4	18.18%	18.18%
4 (4)	9	40.91%	
5 (5)	5	22.73%	63.64%
No answer	0	0.00%	
Arithmetic mean	3.95		
Standard deviation	0.85		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A6(SQ002)

Bitte bewerten Sie die folgenden Aussagen auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Ich kam mit der Bedienung des Spiels gut zurecht.]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	4.55%
2 (2)	1	4.55%	
3 (3)	6	27.27%	27.27%
4 (4)	8	36.36%	
5 (5)	4	18.18%	54.55%
No answer	0	0.00%	
Arithmetic mean	3.79		
Standard deviation	0.85		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A6(SQ003)

Bitte bewerten Sie die folgenden Aussagen auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Die Themen, die das Spiel anspricht, waren interessant für mich.]

Answer	Count	Percentage	Sum
1 (1)	1	4.55%	9.09%
2 (2)	1	4.55%	
3 (3)	3	13.64%	13.64%
4 (4)	9	40.91%	
5 (5)	5	22.73%	63.64%
No answer	0	0.00%	
Arithmetic mean	3.84		
Standard deviation	1.07		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A6(SQ004)

Bitte bewerten Sie die folgenden Aussagen auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Ich würde das Spiel weiterempfehlen.]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	9.09%
2 (2)	2	9.09%	
3 (3)	4	18.18%	18.18%
4 (4)	8	36.36%	
5 (5)	5	22.73%	59.09%
No answer	0	0.00%	
Arithmetic mean	3.84		
Standard deviation	0.96		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A1(SQ001)

p { margin-bottom: 0.25cm; line-height: 120%; } Während ich das Spiel gespielt habe, fühlte ich mich: [Aktiv]

Answer	Count	Percentage	Sum
1 (1)	1	4.55%	13.64%
2 (2)	2	9.09%	
3 (3)	4	18.18%	18.18%
4 (4)	7	31.82%	
5 (5)	5	22.73%	54.55%
No answer	0	0.00%	
Arithmetic mean	3.68		
Standard deviation	1.16		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A1(SQ002)

p { margin-bottom: 0.25cm; line-height: 120%; } Während ich das Spiel gespielt habe, fühlte ich mich: [Energiegeladen]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	13.64%
2 (2)	3	13.64%	
3 (3)	8	36.36%	36.36%
4 (4)	6	27.27%	
5 (5)	2	9.09%	36.36%
No answer	0	0.00%	
Arithmetic mean	3.37		
Standard deviation	0.9		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A1(SQ003)

p { margin-bottom: 0.25cm; line-height: 120%; } Während ich das Spiel gespielt habe, fühlte ich mich: [Lebhaft]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	13.64%
2 (2)	3	13.64%	
3 (3)	9	40.91%	40.91%
4 (4)	6	27.27%	
5 (5)	1	4.55%	31.82%
No answer	0	0.00%	
Arithmetic mean	3.26		
Standard deviation	0.81		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A1(SQ004)

p { margin-bottom: 0.25cm; line-height: 120%; } Während ich das Spiel gespielt habe, fühlte ich mich: [Schläfrig]

Answer	Count	Percentage	Sum
1 (1)	5	22.73%	54.55%
2 (2)	7	31.82%	
3 (3)	5	22.73%	22.73%
4 (4)	1	4.55%	
5 (5)	1	4.55%	9.09%
No answer	0	0.00%	
Arithmetic mean	2.26		
Standard deviation	1.1		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A1(SQ005)

p { margin-bottom: 0.25cm; line-height: 120%; } Während ich das Spiel gespielt habe, fühlte ich mich: [Aufgeregt]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	27.27%
2 (2)	6	27.27%	
3 (3)	6	27.27%	27.27%
4 (4)	7	31.82%	
5 (5)	0	0.00%	31.82%
No answer	0	0.00%	
Arithmetic mean	3.05		
Standard deviation	0.85		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for A3

p { margin-bottom: 0.25cm; line-height: 120%; } Der Schwierigkeitsgrad des Spiels war:

Answer	Count	Percentage
Sehr einfach (A1)	1	5.26%
Einfach (A2)	4	21.05%
Genau richtig (A3)	10	52.63%
Schwer (A4)	4	21.05%
Sehr schwer (A5)	0	0.00%
No answer	0	0.00%

Field summary for B1

p { margin-bottom: 0.25cm; line-height: 120%; } Gab es technische Probleme mit dem Spiel?

Answer	Count	Percentage
Yes (Y)	3	15.79%
No (N)	16	84.21%
No answer	0	0.00%

Field summary for B2

p { margin-bottom: 0.25cm; line-height: 120%; } Beim Herunterladen

Answer	Count	Percentage
Yes (Y)	0	0.00%
No (N)	3	100.00%
No answer	0	0.00%

Field summary for B3

p { margin-bottom: 0.25cm; line-height: 120%; } p { margin-bottom: 0.25cm; line-height: 120%; } Beim Entpacken/Starten

Answer	Count	Percentage
Yes (Y)	0	0.00%
No (N)	3	100.00%
No answer	0	0.00%

Field summary for B4

p { margin-bottom: 0.25cm; line-height: 120%; } p { margin-bottom: 0.25cm; line-height: 120%; } p { margin-bottom: 0.25cm; line-height: 120%; } Schlechte Performance (Spiel läuft zu langsam)

Answer	Count	Percentage
Yes (Y)	0	0.00%
No (N)	3	100.00%
No answer	0	0.00%

Field summary for B5

p { margin-bottom: 0.25cm; line-height: 120%; } Fehler/Abstürze

Answer	Count	Percentage
Yes (Y)	3	100.00%
No (N)	0	0.00%
No answer	0	0.00%

Field summary for B6

Genaue Beschreibung der Probleme:

Answer	Count	Percentage
Answer	3	100.00%
No answer	0	0.00%

ID	Response
14	Am ende liess er mich das spiel nicht beenden und ich musste um diese umfrage zu starten somit den computer runterfahren und das spiel neu starten
16	gebäude wurden nicht fertig gebaut
21	2 Gründstücke ließen sich nicht kaufen (keine Reaktion bei Klicken auf das "$"), wodurch ich mich nach einiger Zeit nicht weiter entwickeln konnte.

Field summary for C1(SQ001)

Bitte bewerten Sie die folgenden Aussagen auf eine Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Das Spiel hat mein Interesse am Thema der Wirtschafts- und Unternehmensethik erhöht.]

Answer	Count	Percentage	Sum
1 (1)	1	4.55%	22.73%
2 (2)	4	18.18%	
3 (3)	5	22.73%	22.73%
4 (4)	9	40.91%	
5 (5)	0	0.00%	40.91%
No answer	0	0.00%	
Arithmetic mean	3.16		
Standard deviation	0.96		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for C1(SQ002)

Bitte bewerten Sie die folgenden Aussagen auf eine Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Das Spiel hat meine Sichtweise auf das Thema der Wirtschafts- und Unternehmensethik geändert.]

Answer	Count	Percentage	Sum
1 (1)	1	4.55%	36.36%
2 (2)	7	31.82%	
3 (3)	7	31.82%	31.82%
4 (4)	4	18.18%	
5 (5)	0	0.00%	18.18%
No answer	0	0.00%	
Arithmetic mean	2.74		
Standard deviation	0.87		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for C1(SQ003)

Bitte bewerten Sie die folgenden Aussagen auf eine Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Durch das Spiel konnte ich meine Kenntnisse auf dem Gebiet der Wirtschafts- und Unternehmensethik erweitern.]

Answer	Count	Percentage	Sum
1 (1)	4	18.18%	45.45%
2 (2)	6	27.27%	
3 (3)	2	9.09%	9.09%
4 (4)	6	27.27%	
5 (5)	1	4.55%	31.82%
No answer	0	0.00%	
Arithmetic mean	2.68		
Standard deviation	1.29		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for C1(SQ004)

Bitte bewerten Sie die folgenden Aussagen auf eine Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Die Komponente der Wirtschaftssimulation stand beim Spielen im Vordergrund.]

Answer	Count	Percentage	Sum
1 (1)	0	0.00%	22.73%
2 (2)	5	22.73%	
3 (3)	5	22.73%	22.73%
4 (4)	7	31.82%	
5 (5)	2	9.09%	40.91%
No answer	0	0.00%	
Arithmetic mean	3.32		
Standard deviation	1		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for C1(SQ005)

Bitte bewerten Sie die folgenden Aussagen auf eine Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Die Auseinandersetzung mit ethischen Fragen stand beim Spielen im Vordergrund.]

Answer	Count	Percentage	Sum
1 (1)	1	4.55%	18.18%
2 (2)	3	13.64%	
3 (3)	6	27.27%	27.27%
4 (4)	8	36.36%	
5 (5)	1	4.55%	40.91%
No answer	0	0.00%	
Arithmetic mean	3.26		
Standard deviation	0.99		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for C1(SQ006)

Bitte bewerten Sie die folgenden Aussagen auf eine Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme voll zu). [Das Spiel ist relevant für meine Ausbildung.]

Answer	Count	Percentage	Sum
1 (1)	6	27.27%	45.45%
2 (2)	4	18.18%	
3 (3)	4	18.18%	18.18%
4 (4)	4	18.18%	
5 (5)	1	4.55%	22.73%
No answer	0	0.00%	
Arithmetic mean	2.47		
Standard deviation	1.31		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for D1

p { margin-bottom: 0.25cm; line-height: 120%; } Das Fach Wirtschafts- und Unternehmensethik interessiert mich.

Answer	Count	Percentage	Sum
1 (1)	2	9.09%	13.64%
2 (2)	1	4.55%	
3 (3)	2	9.09%	9.09%
4 (4)	10	45.45%	
5 (5)	4	18.18%	63.64%
No answer	0	0.00%	
Arithmetic mean	3.68		
Standard deviation	1.2		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for D2

p { margin-bottom: 0.25cm; line-height: 120%; } Wie oft spielen Sie Computerspiele?

Answer	Count	Percentage
Nie (A1)	10	52.63%
Einmal im Monat oder seltener (A2)	6	31.58%
Einmal in der Woche (A3)	2	10.53%
Mehrmals in der Woche (A4)	1	5.26%
Täglich (A5)	0	0.00%
No answer	0	0.00%

Field summary for D3

p { margin-bottom: 0.25cm; line-height: 120%; } Ich habe Erfahrung mit dieser Art von Spielen (Wirtschaftssimulationen). p { margin-bottom: 0.25cm; line-height: 120%; } p { margin-bottom: 0.25cm; line-height: 120%; }

Answer	Count	Percentage	Sum
1 (1)	6	27.27%	40.91%
2 (2)	3	13.64%	
3 (3)	0	0.00%	0.00%
4 (4)	5	22.73%	
5 (5)	5	22.73%	45.45%
No answer	0	0.00%	
Arithmetic mean	3		
Standard deviation	1.7		
Sum (Answers)	19	100.00%	100.00%
Number of cases	19	100.00%	

Field summary for D4

Bitte nennen Sie ihr Geschlecht:

Answer	Count	Percentage
Female (F)	12	63.16%
Male (M)	7	36.84%
No answer	0	0.00%

Field summary for D6

Studieren Sie an der Universität Mannheim?

Answer	Count	Percentage
Yes (Y)	18	94.74%
No (N)	1	5.26%
No answer	0	0.00%

Field summary for D5

Welchen Studiengang studieren Sie?

Answer	Count	Percentage
Bachelor BWL (A1)	17	94.44%
Other	1	5.56%
No answer	0	0.00%

ID	Response
6	B.A.KuWi

Field summary for E1

p { margin-bottom: 0.25cm; line-height: 120%; } Was hat Ihnen am Spiel besonders gut gefallen?

Answer	Count	Percentage
Answer	7	36.84%
No answer	12	63.16%

ID	Response
4	Nähe zu Anno-Grafiken Tolle Zeichnungen
6	Es war sehr anspruchsvoll alle Interessen zu befriedigen. Ich konnte mich richtig in den Unternehmer hineinversetzen und sah, dass es nicht so einfach ist allen gerecht zu werden.
9	besonders viele Funktionen und Korrelationen
11	das Outfit!
15	- man wird von Stakeholdern unter Druck gesetzt - man muss relativ schnell Entscheidungen treffen - allgemein eine gute Idee
17	Anfänglich war es wirklich herausfordernd, aber nach der ersten großen Fabrik kam der Erfolg wie von selbst.
21	Sehr komplex; man musste neben allen Stakeholdern auch die Nachfrage und die Investitionsplanung im Auge behalten. Es gab immer was zu tun!

Field summary for E2

p { margin-bottom: 0.25cm; line-height: 120%; } Was hat Ihnen am Spiel nicht gefallen? Haben Sie Verbesserungsvorschläge?

Answer	Count	Percentage
Answer	10	52.63%
No answer	9	47.37%

ID	Response
4	Bessere Rate der Bekanntheit erkennbar
5	Manchmal waren die Zusammenhänge nicht ganz klar, beispielsweise warum man auf einmal keine Angestellten mehr einstellen konnte...
6	Manchmal hat es etwas langsam geladen.
7	-zu viele pop ups -Anno 1602 Grafik
11	Bedienung. man findet nach Inselausflg die eigenen Fabriken kaum. Instruktionen: Wie man was bedient ist oft fraglich, wird erst durch den Instruktor erklärt. , womit kann man Umsatz steigern (durch Buchhalter zuerst!) darauf kommt man nur durch Raten. Ab wann kann man Kampagnen startet, wie gewinnt man der Spiel etc .das erfährt man erst, wenn man lange spielt... Vielleicht müsste der manager, der einen leitet, mehr erklären..
15	- manchmal wusste man nicht genau wie es weiter geht allgemeiner Verbesserungsvorschlag: wir wollten es in der Ethikvorlesung spielen, leider hat der Download nicht geklappt, da alle gleichzeitig darauf zugegriffen haben... eventuell Link vorher zur Verfügung stellen
17	Nach hinten heraus wurde es zu langweilig. Ich habe im Monat 5 Mio. verdient und in Naturschutzgebieten und nahe der Stadt produziert. Der einzige Stakeholder, der unzufrieden war, war allerdings mein "Chef" und nicht etwa die Aktivisten. Das fand ich etwas unrealistisch.
18	Macht super viel Spaß, Shortcuts für das öffnen der einzelnen Menüs wären super. Entdecken der Vorspulmöglichkeit war extrem wichtig! Großes Lob!!!
21	Wer einem großen Textilkonglomerat angehört, sollt anfangs keine Probleme haben mit zu geringer Nachfrage, aber genau das war das Problem: Man konnte nicht einfach schnell wachsen, sondern musste sich quälend viel Zeit nehmen, Nachfrage und Produktion in etwa gleich zu halten...
23	eventuell könnten Wartezeiten verkürzt werden

A.2. Biology Game

Table A.1.: Questions for the game world coherence study.

#	Statement
Situational Interest	
SI1	The questions about biology are exciting.
SI2	The questions engage my attention when playing the game.
SI3	The biology question are so exciting that it is easy to pay attention to them.
SI4	What I learn in this game is fascinating me.
SI5	The biology question that I answered in the game are of interest for me.
SI6	I can use the learning outcomes of the game in my biology courses.
SI7	The learning outcomes of this biology game are important for me.
SI8	I am able to use the learning outcomes of this biology game in my daily life.
SI9	I would like to get to know more about the topic “the human body”.
SI10	The game caught my interest in the topic “the human body”.
Individual Interest	
II1	It is of interest for me to know the biology of the human body.
II2	Knowledge about biology helps me in my daily life outside of school.
II3	It is important to me to be a person who argues scientifically.
II4	I am enjoying the subject of biology.
II5	I like biology.
Arousal	
A1	When I was playing the game I felt active.
A2	When I was playing the game I felt energetic.
A3	When I was playing the game I felt vigorous.
A4	When I was playing the game I felt sleepy.
A5	When I was playing the game I felt excited.
Flow: Focused Immersion	
FI1	While playing the game I am able to discard any form of distraction.
FI2	I am absorbed in what I am doing while playing the game.
FI3	I am easily distracted while playing the game.
FI4	Answering the questions during the game poses a distraction.
FI5	Conquering platforms in the game posed a distraction form answering questions.

Table is continued on the next page.

Table A.1.: Questions Biology Game, continued.

Flow: Heightened Enjoyment	
FE1	I enjoyed playing the game.
FE2	Playing the game bored me.
Flow: Temporal Dissociation	
FD1	Time flies by while playing the game.
Satisfaction	
S1	Summarizing, I was satisfying with playing Word Domination.
S2	Answering questions in Word Domination was satisfying.
Perceived Learning	
L1	I think that I know more about the topic “the human body” after playing the game.
L2	I think that playing the game helped me to answer the questions better.
L3	I think that the game helped me to memorize the learned knowledge.
General Questions	
G1	I had no problems with controlling the game.
G2	It was easy for me to find my way around in the game.

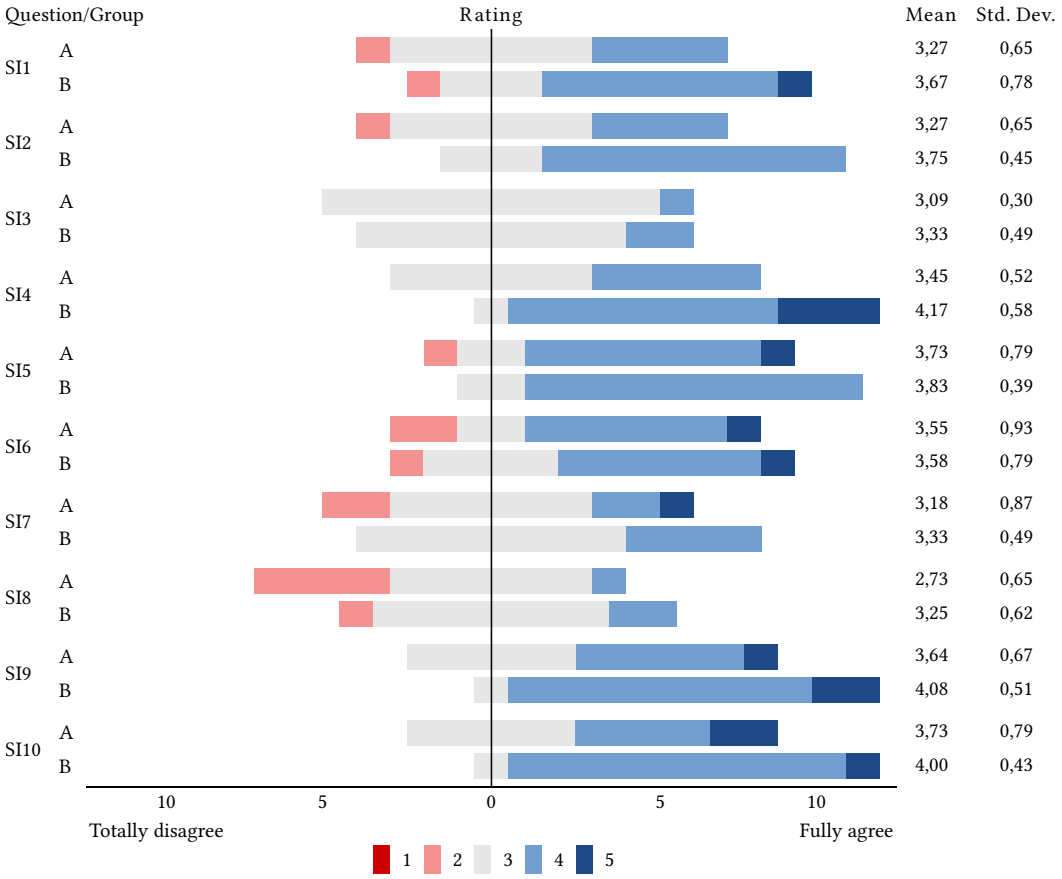


Figure A.1.: Results from the study on the influence of game environments in the question group of **Situational Interest** (see Table A.1). The bars show the distributions of the five point Likert scale.

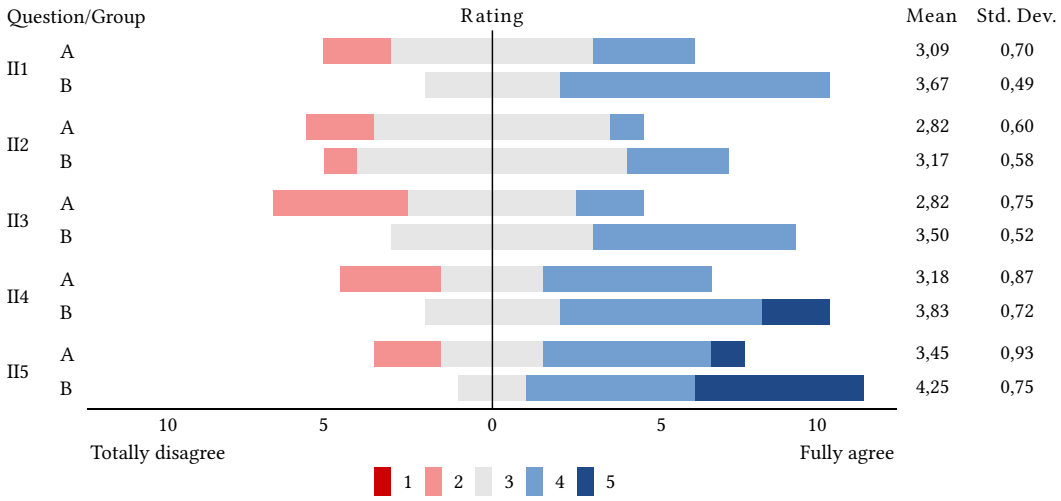


Figure A.2.: Results from the study on the influence of game environments in the question group of **Individual Interest** (see Table A.1). The bars show the distributions of the five point Likert scale.

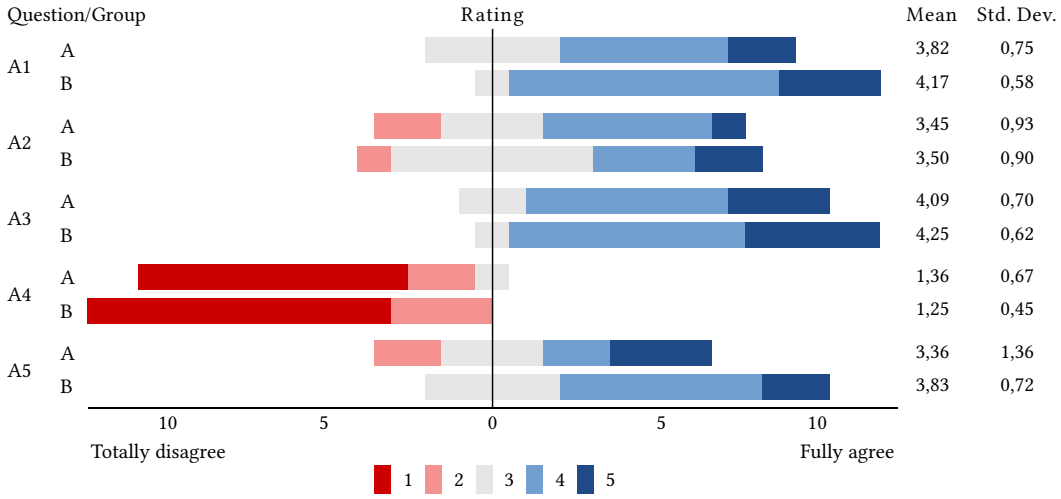


Figure A.3.: Results from the study on the influence of game environments in the question group of **Arousal** (see Table A.1). The bars show the distributions of the five point Likert scale.

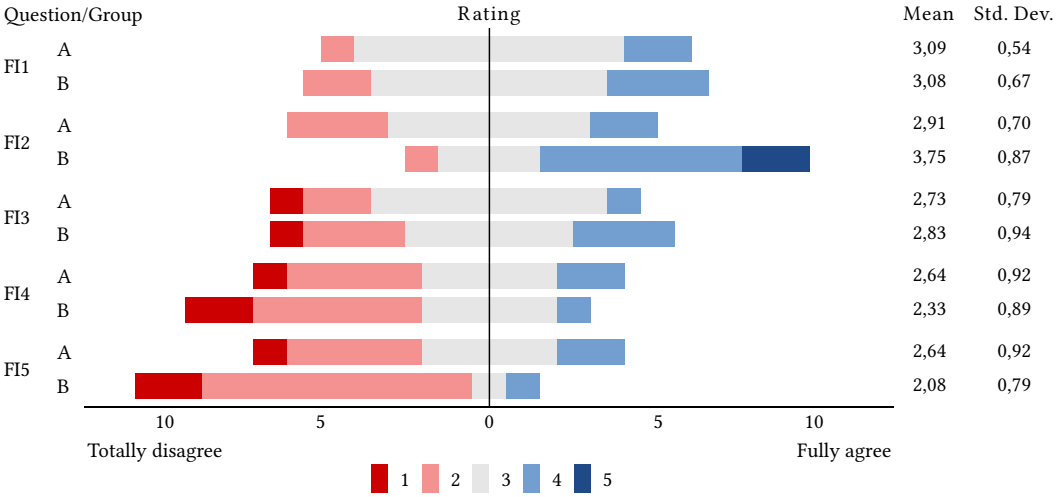


Figure A.4.: Results from the study on the influence of game environments in the question group of **Flow: Focused Immersion** (see Table A.1). The bars show the distributions of the five point Likert scale.

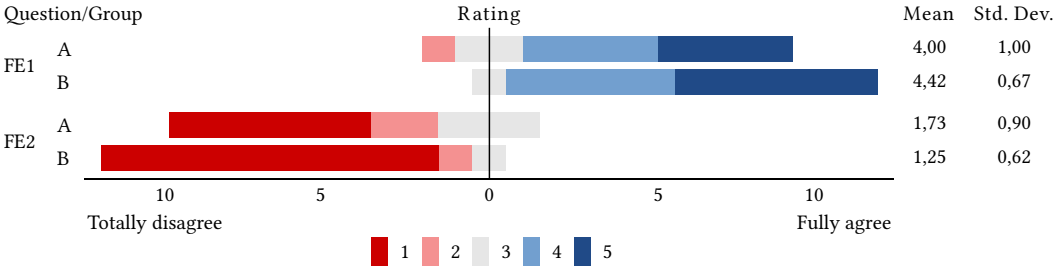


Figure A.5.: Results from the study on the influence of game environments in the question group of **Flow: Heightened Enjoyment** (see Table A.1). The bars show the distributions of the five point Likert scale.

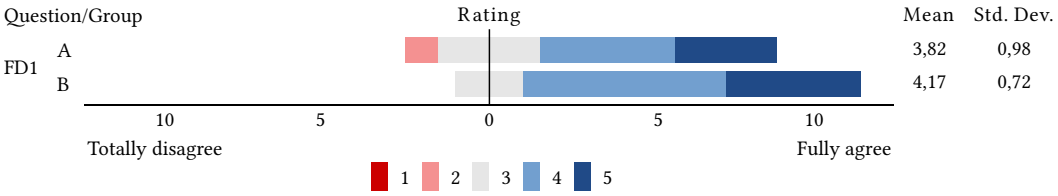


Figure A.6.: Results from the study on the influence of game environments in the question group of **Flow: Temporal Dissociation** (see Table A.1). The bars show the distributions of the five point Likert scale.

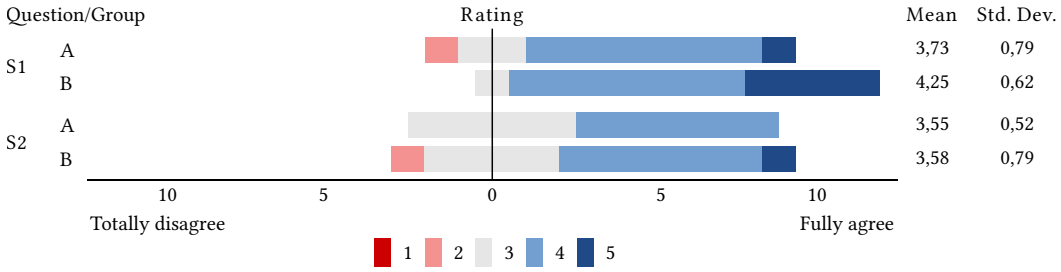


Figure A.7.: Results from the study on the influence of game environments in the question group of **Satisfaction** (see Table A.1). The bars show the distributions of the five point Likert scale.

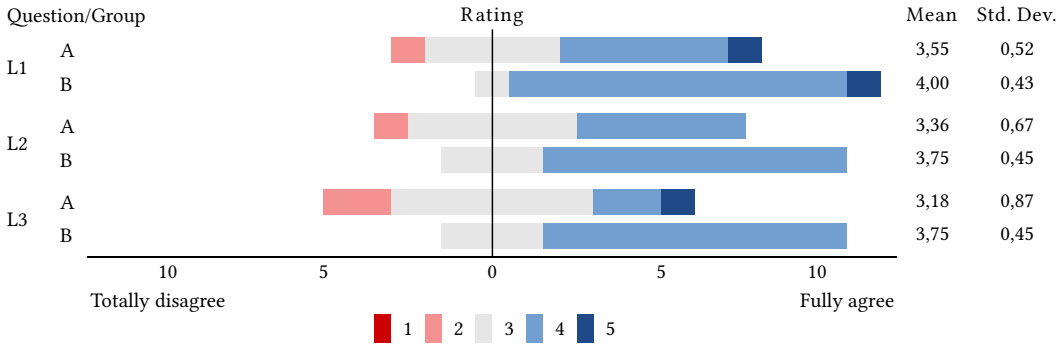


Figure A.8.: Results from the study on the influence of game environments in the question group of **Perceived Learning** (see Table A.1). The bars show the distributions of the five point Likert scale.

Figure A.9.: Results from the study on the influence of game environments in the question group of **General Questions** (see Table A.1). The bars show the distributions of the five point Likert scale.

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Referenced Games

Age of Empires RTS game series. The single-player campaigns as well as the playable parties reference historical events and peoples of mankind, starting with the Stone Age and reaching up to the Industrial Age. 36, 55, 130

`http://www.ageofempires.com/`

America's Army FPS war simulation game released by the U.S. army as a recruiting tool. It is considered to be the first largely successful serious game. 2, 35, 48

`http://www.americasarmy.com/`

Angry Birds Mobile game series. Players have to demolish structures by throwing different kinds of birds at them. As such, the game teaches basic knowledge about physics. 59

`https://www.angrybirds.com/`

Ayiti: The Cost of Life Game that addresses poverty and hunger. It employs a mix of business simulation games and life simulations such as *The Sims*. 45

`https://ayiti.globalkids.org/game/`

Battlefield FPS game series. It focuses on online multiplayer battles that are located in historic of fantasy war zones. 45, 48, 131

`http://www.battlefield.com/`

Beer Game Business simulation game where players have to build up a supply chain for producing and selling beer. It is often used as an example for showing the bullwhip effect (Goodwin and Franklin, 1994). 46

Blindscape Mobile game that does not use the screen as output device. Player are limited to audio and haptic feedback to solve riddles in a small adventure game. 61

`http://www.blindscapegame.com/`

Call of Duty FPS game series. The game reference actual historic war zones or play in fantasy settings. 21, 45, 131

`https://www.callofduty.com/`

Civilization Turn-based strategy game series. The episodes that reference human history are being known for containing a lot of historically correct information. 36, 40, 43, 44, 55, 74, 130

`http://www.civilization.com/`

Crysis FPS game series with a focus on providing the latest 3D graphics in a realistic fantasy setting. 31, 242

`http://www.crysis.com`

Dance Central Music rhythm game where players have to reenact dance moves. It uses the *Microsoft Kinect* as input controller. 47

`http://www.harmonixmusic.com/games/dance-central/`

Dance Dance Revolution Music rhythm game where players have to reenact dance moves. It requires a dedicated dance mattress that acts as input controller. 22, 47, 59

`http://www.ddrgame.com/`

Darfur is Dying Newsgame addressing the crisis in Darfur. 45, 60

`http://www.darfurisdying.com/`

Dr. Kawashima's Brain Training Game series that includes small puzzle games. 60

Fatworld Game that critically addresses the politics of nutrition in the U.S. of today. 47

Frontiers Addressed the path refugees have to take to get to Europe. Players take the role of refugees and have to cope with problems at different stages of the path, including getting across the border and avoid being revealed. 45

`http://www.frontiers-game.com/`

Grand Theft Auto Open world action game series. As of 2015, the fifth part was one of the most expensive game ever made with a total budget of $265 million. 112

`http://grandtheftauto.com/`

Guitar Hero Music rhythm game series. It uses a physical guitar model as input controller to reenact real guitar play. 22

`https://www.guitarhero.com/`

Half-Life FPS game series that is known for strong scripting-based story elements in a futuristic science fiction setting. 74

`http://www.half-life.com/`

Halo FPS game series that employs a science fiction setting. 22

`https://www.halowaypoint.com`

I'll Get it! Library game by the *Carnegie Mellon University* library. Players have the task of looking up the correct literature to a given search query. 122

`https://libwebspace.library.cmu.edu/libraries-and-collections/Libraries/etc/game2/game2.swf`

Ingress Location-based mobile game. Two factions play against each other and can divide parts of the real world between them by virtually conquering and holding certain areas. 122

`https://www.ingress.com/`

It's Alive! Library game by the *Lycomming College*. Player get to know the different library services by answering questions in a web-based application. 122

`http://www.lycoming.edu/library/instruction/tutorials/itsAlive.aspx`

Lemontree Gamification application for the *University of Huddersfield*. Players can score points or achievements by using the regular library services such as lending books or by checking into the library. 123

`https://library.hud.ac.uk/lemontree/`

LibHunt Web-based library game by the *Rochester Institute of Technology*. Players have to solve a row of quizzes and tasks to get to know the library. 122, 123

`https://library.rit.edu/libhunt/campus`

Madden NFL Sports game series about American football. New episodes are released on a yearly basis. 22

`https://www.easports.com/madden-nfl`

Making History Series of strategic turn-based games about the First and the Second World War. 74

`http://making-history.com/`

Minecraft Sandbox game set in a world made out of blocks that can be edited by players. Besides the pure sandbox mode, a story mode was added later. 26, 74, 96

`https://minecraft.net/`

Pac-Man Series of early arcade games. Players have to collect pellets in a maze while trying to avoid four ghosts that chase the player. 62

`http://pacman.com/`

PeaceMaker Game about the conflict in the Middle East. Player can take the side of Israel or Palestine to experience the inner conflicts of both parties. 45

`http://www.peacemakergame.com/`

Project Spark Sandbox game that lets players create own game modules from within the game environment. 74

`http://www.projectspark.com/`

Quest Atlantis Game-based application that features a story-based 3D multiuser environment. The goal is to teach 9–15 year old children the inquiry of meaningful tasks[1]. 43

Re-Mission Game used in cancer therapy. Players virtually travel through the own body and fight cancer cells in a third-person shooter game. 47, 162

`http://www.hopelab.org/re-mission/`

Saving Sergeant Pabletti Training game used by the U.S. army. 48

`http://willinteractive.com/products/saving-sergeant-pabletti`

September 12th Newsgame about the September 11 attacks. Its intention is to show players that violent acts will only result in more violence and aggression. 45

`http://www.newsgaming.com/games/index12.htm`

SimCity Simulation game series about building up and managing whole cities. 36, 45, 130, 238

`http://www.simcity.com/`

SimCityEDU Educational variant of *SimCity* by GlassLab[2]. 45

`https://www.glasslabgames.org/games/SC`

Spent Newsgame about poverty in the U.S. where players have to try to get along with a small amount of money. Losing the game is an integral part of the gameplay. 45, 60

`http://playspent.org/`

Sweatshop Newsgame that addresses in shortcomings the textile industry. Players have to produce clothes in a tower defense style game while dealing with issues like rundown factories and child labor. 45, 102

`http://www.playsweatshop.com`

Tactical Iraqi Training game used by the U.S. army *"to accelerate a soldier's acquisition of spoken Arabic to assist in volatile tactical situations"* (Losh, 2006). 48

Tetris Puzzle game originally released in 1984. Player have to build rows by stacking different kinds of blocks. 41

`http://tetris.com/`

[1] `https://en.wikipedia.org/wiki/Quest_Atlantis`, accessed 17.09.2015.
[2] `https://www.glasslabgames.org/`

The Magic Circle Puzzle game that takes up on the concept of the *Magic Circle* (see Section 2.2) in a humorous way. Players are placed into an unfinished game that they have to complete. 74

`http://www.magiccirclegame.com/`

The Sims Life simulation game series where players can build up homes for virtual characters the control indirectly, forming families or relationships. 11, 43, 47, 112, 235

`https://www.thesims.com`

The Typing of the Dead Game for learning typing on a keyboard. Approaching enemies have to be defeated by typing words that appear on the respective enemies. 61

This War Of Mine Survival game that lets players experience war from the perspective of civilians that try to survive in a war zone. 45

`http://www.11bitstudios.com/games/16/this-war-of-mine`

Tropico Construction and management simulation game series that is set in an alternate reality where players have to build up a socialist community on a tropical island. 102, 103

`http://www.worldoftropico.com`

ULB-Online-Spiel Library game by the university library Münster that lets players learn the services of the library in an adventure game. 122, 123

`http://www.ulb.uni-muenster.de/ulb-tutor/tutorials/ulbgame/ulbgame.html`

Unreal FPS game series set in a futuristic fantasy world. 31, 239, 244

Unreal Tournament FPS multiplayer game series set in the *Unreal* universe. 131, 244

`https://www.unrealtournament.com/`

Virtual Iraq Treatment game used by the U.S. army *"to lessen the effects of Post-Traumatic Stress Disorder among combat veterans"* (Losh, 2006). 48

Web Earth Online Multiplayer game environment where players learn about earth and the environment from the perspective of animals. 44

`http://www.webearthonline.com/`

Where in the World Is Carmen Sandiego? 2D adventure game that teaches geography in a stealth learning approach by letting players virtually visit countries around the world. 59

Wii Fit Sports game that promotes workouts with the use of the Nintento *Wii* controllers. 47

`http://www.wiifit.com/`

Within Range Library game by the *Carnegie Mellon University* library. It teaches the cataloging system how literature is sorted in the library. 122

`https://libwebspace.library.cmu.edu/libraries-and-collections/Libraries/etc/game1/game1.swf`

Word of Warcraft MMORPG that started in 2004 and temporarily counted more that 12 million paying subscribers (Blizzard Entertainment, 2010). 15, 43, 45

`http://eu.battle.net/wow/en/`

Glossary

Active Worlds Sandbox platform that lets users create own levels (worlds) from within the 3D environment. Created worlds can be shared with the community. 43

`http://www.activeworlds.com`

ADRIFT The *Adventure Development & Runner – Interactive Fiction Toolkit* can be used to create text-based adventures in a visual editor. 71

`http://www.adrift.co/`

Adventure Game Studio Framework for creating adventure games. It provides visual editors that do not require programming knowledge, but is also extensible via scripting support. 71

`http://www.adventuregamestudio.co.uk/`

Alice Tool that teaches programming skills by letting players create custom story-based animations in an integrated development environment (IDE) that employs a simple visual scripting language. 73, 130

`http://www.alice.org/`

AndEngine Game engine for creating mobile application for the Android platform. OpenGL ES is used to provide accelerated graphics output[3]. 71

`http://www.andengine.org/`

AngularJS Open-source web application framework that focuses on providing responsive singe page applications[4]. 113

`http://www.angularjs.org/`

ARIS Open-source platform for creating and playing mobile games, tours and interactive stories. It employs location-based tasks as well as the integration of QR code functionality. 72

`http://arisgames.org/`

Blender Open source 3D creation suite that supports the whole 3D pipeline-modeling, including creation of 3D models, animation. Apart from modeling tasks it can also be used to create whole movies or games. 104

`https://www.blender.org/`

[3] `https://en.wikipedia.org/wiki/AndEngine`, accessed 08.07.2015.
[4] `https://en.wikipedia.org/wiki/AngularJS`, accessed 30.10.2015.

CakePHP Web framework based on PHP that works with a model view controller (MVC) pattern. 133

`http://cakephp.org/`

Construct 2 HTML5 game creation tool designed for 2D games. Games can be created in an IDE that does not require programming knowledge. 71

`https://www.scirra.com/construct2`

CryEngine Commercial game engine that is developed by the German game developer Crytek. Supported programming languages are C++ and Lua. Major titles created with it include the *Crysis* series[5]. 71

`http://cryengine.com/`

Flask Web microframework for Python. 113

`http://flask.pocoo.org/`

GameGuru Game creation tool made by *The Game Creators* with focus on FPS games. Game content and logic can be created in a visual editor. 72

`https://www.game-guru.com/`

GameMaker Creation tool for cross-platform games geared towards entry-level novices and seasoned game development professionals with optional scripting support. 71

`http://www.yoyogames.com/studio`

GameSalad HTML5 game creation tool with focus on simplicity, targeting novice game developers. 71

`http://gamesalad.com/`

Gamestudio Game and animation engine that offers different levels of complexity and freedom by supporting scripting with lite-C and further programming with C++ or C#. 71

`http://www.conitec.net/english/gstudio/`

Hot Potatoes Application suite for generating small web-based learning games based on elements such as quizzes and crosswords. 73

`http://hotpot.uvic.ca/`

Image Composite Editor Advanced panoramic image stitcher created by the Microsoft Research Computational Photography Group. 113

`http://research.microsoft.com/en-us/um/redmond/projects/ice/`

[5] `https://en.wikipedia.org/wiki/CryEngine`, accessed 15.07.2015

jMonkeyEngine Open-source cross-platform game engine based on Java. 71

`http://jmonkeyengine.org/`

Kodu Game Lab Teaches programming skills by letting users — specifically children — create custom games within the application with a simple visual programming language. 73

`http://www.kodugamelab.com/`

LearningApps.org Web-based application suite for generating learning games. New games can be created based on a set of predefined templates without any programming effort. The creation of new templates is supported through an extensible API. 73, 75, 150

`http://learningapps.org/`

MissionMaker Game creation tool for simple 3D adventure games. It also acts as a teaching tool for game design and development. 73

`http://creativeedutech.com/products/missionmaker/`

Oculus Company offering virtual reality tools for input controllers (*Oculus Touch*) and output devices (*Rift*). 20

`https://www.oculus.com`

Play Framework Open-source web application framework, written in Scala and Java based on the MVC architectural pattern[6]. 152, 155

`http://www.playframework.com`

QR code Quick Response Codes are a machine-readable optical label that contain information about the item to which it is attached. The encoded information may contain URLs or arbitrary text[7]. 123–126, 129, 241

Ren'Py Visual novel engine that allows to create narratives with a specialized scripting language based on Python. 71

`http://www.renpy.org/`

RPG Maker Game creation tool specialized for RPGs. Geared towards novice game developers as well as professionals. 71

`http://www.rpgmakerweb.com/`

[6] `https://en.wikipedia.org/wiki/Play_framework`, accessed 22.06.2015.
[7] `https://en.wikipedia.org/wiki/QR_code`, accessed 04.11.2015.

Sandbox Game Maker Open-source game creation tool based on the cube 2 engine that allows users to model game worlds from within the application. 71

`http://www.sandboxgamemaker.com`

Scratch Tool for creating simple 2D interactive stories or games with an easy-to-use visual editor. The project of the Lifelong Kindergarten Group at the MIT Media Lab can be used to teach basic programming skills. Created projects can be shared with the community. 73, 130

`https://scratch.mit.edu/`

Scroller Game Creator Tool for creating side scroller games. Making new games does not require any programming knowledge. 72

`http://percsich.hu/sgc/index.php`

Silent Works Company that offers a set of game creation tools. Each one is geared towards certain game genres, including FPSs, scroller games, adventures or mobile games. 72

`http://www.silentworks.hu/`

SmartFoxServer Multi-platform client/server framework made for providing server capabilities for multiplayer games. It is extensible by adding Java--based extensions with custom logic. 133

`http://www.smartfoxserver.com/`

Tower Defense Toolkit *Unity* plugin that provides tower defense game modes as a ready-to-use and extensible toolkit. 151

`http://song-gamedev.blogspot.de/p/blog-page_27.html`

Unity3D Cross-platform commercial game engine developed by Unity Technologies. The mainly used programming languages are C# and JavaScript[8]. 71, 75, 94, 104, 133, 136, 151, 244

`http://unity3d.com/`

Unreal Engine Commercial game engine developed by Epic Games. The mainly used programming language is C++. Major titles that use this engine include the *Unreal* and *Unreal Tournament* series. 71

`https://www.unrealengine.com`

uWebKit *Unity* plugin that allows to embed arbitrary web content into game clients as overlay. 152

`http://uwebkit.com/`

[8] `https://en.wikipedia.org/wiki/Unity_(game_engine)`, accessed 22.06.2015.