Introduction

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Abstract

This chapter introduces the basic subject of this book: serious games. Besides a definition of the term serious game, related fundamental concepts and terms such as gamification, gaming, and playing or game mechanics are detailed. Reasons for using serious games and for delving into this subject are discussed. To better understand a serious game and its context, a reference scenario is provided. Moreover, as a frame of reference, the development process of a digital game is sketched, and the peculiarities of serious games development are highlighted. A short history of serious games provides some background on the subject. This is followed by some general hints for how to use this book. Suggestions are provided for different target groups (e.g., prospective developers or prospective users) for how to best utilize this textbook. Finally, as in every chapter of this book, a summary is given, accompanied by a set of questions for self-assessment and recommendations for further reading.

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1.1 What Are Serious Games?

People love being entertained. People love playing games. Human history indicates that games have been played in all societies. Some ancient board games such as *Go* or *Backgammon* are still in use today, although they have predecessors that date back more than 5,000 years. Games can be considered a specific form of playing behavior, with characteristics such as rules and an identifiable outcome. For example, while it may be entertaining to try to hit a target with a ball, this is just playing with a toy—not a game. If a set of rules is obeyed by the players (e.g., the target is a hoop 46 cm in diameter and is mounted 3 m above the ground) and points are awarded according to rules making quantifiable who is in the lead, this playing activity is said to be a game (basketball).

Balls, dice, cards, and other artifacts have been used for playing games. Given the fondness of humans for gameplay, it is no wonder that the computer as a technical artifact has also served as a basis for games.

> Games that use some kind of computing machinery (e.g., a personal computer, a smartphone or a piece of electronics dedicated for playing games such as a video game console) are called *digital games*.

Digital games have been immensely successful. Computer game software has wide user demographics ranging from toddlers to users well advanced in years, encompassing all social groups. More than 50 % of all households in the U.S., for instance, own a video game console (Ipsos Media CT 2013). This success is also reflected in the market volume of digital games. According to one study (Gartner Inc. 2013), the worldwide marketplace for digital games is estimated to be $93 billion USD in 2013, with a growth rate of more than 17 % over 2012. This mass market, and investments in the industry, fuel a dynamic development in game technology. For example, Microsoft's Kinect depth camera for the Xbox game console provides 3D sensing technology that is not only an acceptable alternative to similar products used in non-gaming applications, but also because of the economies of scale more affordable, costing an order of magnitude less. So, why not use game technology for non-gaming applications? Why not take advantage of the success of digital games in application areas beyond entertainment?

It is not only the technological advances that make digital games attractive for pursuing objectives different from pure entertainment. Sophisticated methodologies have been developed for digital games. For instance, game designers acquired skills that can be used to emotionally involve players in a digital game (Freeman 2003). Digital game methodologies have also become an area of research. Researchers were able to identify important factors for game enjoyment besides the technical capacity, such as aesthetic presentation or narrativity (John and Srivastava 1999).

Digital games can also be intrinsically motivating (Wong et al. 2007). They are even capable to put players into the mental state of flow (Csikszentmihalyi 1990), where they feel fully immersed in, and absorbed by, an activity. Would it not be desirable to use a digital game to put learners into this flow state, where they would be highly focused on their learning activity? Would it not be advantageous to employ digital games in order to turn learning into an enjoyable experience where time flies by?

Television is an example of a new medium where a while after its introduction the applicability for purposes such as learning has been explored (e.g., by producing television formats such as Sesame Street). Why not do the same with digital games? Traditional games have been used for more serious purposes than entertainment. For example, the board game *Monopoly* was created with the intention to serve as a tool to teach the negative effects of monopolies on the economy (Orbanes 2006). Sport games such as basketball can be played not only for a fun experience, but also because players strive to increase their fitness and improve their health. If traditional games are able to serve other purposes than entertainment, why should digital games lack this ability? We call a digital game that possesses this ability a *serious game,* and define the term as follows:

> A *serious game* is a digital game created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health). These additional goals are named *characterizing goals*.

Today, the term serious game is somewhat vague because no universally accepted definition exists. In other definitions, serious games are not characterized by the intention of the developer, but by the intention of the player. Thus, a digital game such as the ego-shooter *Doom* would become a serious game if the player uses it not only for entertainment, but also to train motor skills or to improve reaction time. Moreover, some definitions distinguish serious games from other games by requiring that they are played not in a formal educational setting, but voluntarily in the player's leisure time. In our definition, there are no demands made that the serious game actually meets its goals. The mere intention of the developers is sufficient to categorize a game as a serious game. This is not the case in other definitions of the term. Michael and Chen (2006) define a serious game as a game that does not have entertainment, enjoyment, or fun as their primary purpose. In our definition, the goals of a serious game are not ranked by their importance. While we require a serious game to be a digital game, others specify the term more generally and apply it to all types of games. In fact, Abt (1970) coined the term *serious games* with only board and card games in mind.

Serious games are not a particular game genre. For instance, a serious game could be an action adventure, a strategy game, or a sports game. Serious games also need to be distinguished from gamification. *Gamification* is the transfer of game methodologies or elements to non-game applications and processes (Deterding et al. 2011).

For example, the sports apparel manufacturer Nike uses badges, achievements, challenges, and rewards in their customer loyalty program—concepts typically found in games. Thus, the result of gamification is not necessarily a game.

Often, serious games are intended for learning. For example, *Jetset* (Persuasive Games LLC 2014) is a mobile game that allows travelers to keep up to date with current security regulations at 100 international airports. Players not only learn whether they have to take their shoes off at a particular airport, but they can also strip search other virtual travelers for fun and obtain virtual souvenirs. In addition to learning simple facts, serious games can also pursue more complex goals such as the acquisition of specific skills. Disney's *Minnie explores the land of Dizz* (The Walt Disney Company Ltd. 2014) is an example of a serious game where small children can develop problem solving skills. The simulation game *INNOV8* from IBM (IBM Corp. 2014) provides learning opportunities for IT and business professionals to grasp the effects of business process management.

Learning is not the only characterizing goal of serious games. There is a whole range of other characterizing goals. *America's Army* (Knight 2002) provides a soldiering experience of basic training and is used as a tool for recruitment. *Re-Mission* (HopeLab 2014) is a serious game for young cancer patients where they have to control a nanobot to fight cancer and infections in the human body. The game intends to inform patients about cancer treatments and to positively change their attitude (in this case, towards a strict adherence to chemotherapy treatments). *SnowWorld* (Hoffman 2000), a first-person shooter with snowballs, is a serious game that tries to distract burn victims from pain during wound treatment by immersing them in a virtual world.

Serious games can be divided into categories according to their characterizing goals. For example, *exergames* encourage people to become physically active and sustain a healthy lifestyle, whereas *advergames* are used for marketing purposes or recruiting and may raise the players' awareness of certain topics. The characterizing goals of today's serious games also include lifestyle behavior change, medical diagnosis, enterprise management, decision support, development of social skills, analysis of causal mechanisms, creation and defense of arguments, development of conflict resolution strategies, arousal of fantasy, elevation of civic engagement, promotion of ethical values, persuasion and recruitment to causes, campaigning in politics, and many more.

1.2 Motivation

There are many motivations for those interested in creating a serious game and pursuing goals beyond entertainment with it. First, creators want to provide the users with a fun experience: the sensory pleasure (e.g., nice visuals and sounds) of a well-made game can contribute to making the software enjoyable to use. An interesting narration is another factor that can increase the enjoyment.

Second, it is difficult to increase user motivation, and games can provide a tool to accomplish this. For example, a joyful experience can motivate users and generate interest or curiosity. Factors inherent in many games such as achievement and control have been shown to contribute to motivation.

Third, software creators aim to reach users on an emotional level. Good gameplay should be able to evoke challenge, suspense, thrill, relief, empathy with characters, or caring for an environment. This can foster active engagement. Game creators intend to have their users lean forward and not lean back when using the software. As a result, the users may be more committed or invest higher levels of endurance and effort. This can be highly supportive to achieve the intended goals of a serious game.

Fourth, the level of goal achievement with serious games might be higher than with other means. For instance, there are reports that serious games foster sustained learning (Michael and Chen 2006). The advantages of using a narrative (e.g., quicker comprehension and better remembrance, Graesser and Ottati 1996) can be exploited in narrative serious games, which are unique in the sense that the user is able to interactively influence the development of a story, in contrast to other media for narratives such as books or videos. The *SnowBall* game was reported to be as effective in achieving the goal of pain reduction as morphine, while avoiding the adverse effects of the drug (Hoffman 2000).

Fifth, serious games offer immediate feedback and adaptability. As games have a quantifiable result, players are immediately able to assess their progress. Since assessment is accomplished by an anonymous system, players might perceive the assessment to be less stressful or embarrassing. Based on the assessment, the game software can adapt parameters—for example, the difficulty level—to the individual player. As a result, serious games are capable of providing users with a cognitive, emotional, or physical challenge that is neither too easy nor too difficult.

Sixth, serious games can be a smart tool to achieve a certain goal where there are simply no equivalent alternatives. For example, serious games are capable of engaging a user in a simulated hypothetical world, where contradictions or anomalies are integrated to induce problem-solving strategies and increase their self-efficacy in case of success.

These are six of the major reasons to explore and employ serious games as a tool for achieving a variety of goals. Additionally, there are other reasons to concern oneself with serious games, such as taking advantage of market opportunities or fostering social experiences by using multiplayer game technology.

However, employing serious games may not only have positive consequences. The term serious game itself is an oxymoron—a game that is serious appears to be a contradiction. Indeed, players might be demotivated to play a game simply because it is labeled to be serious. Players might perceive a serious game as a feeble attempt to wrap something that is not pleasant in a nice box—and find serious games as appealing as chocolate-coated spinach. Just because something is a game does not mean that it is fun (Wong et al. 2007). Serious games have the inherent tradeoff, where they are trying to achieve more than one goal. If the goal to entertain is neglected, the playing experience might be negative. Even worse, players might

fear that they are manipulated by a serious game. In his science fiction novel *Ender's Game,* Card (1985) describes a serious game where an action game is used to trick children to fight a real war where they take ruthless decisions because they assume that it is only a game. Games in general have not only positive traits, for example, there is the problem that games might be addictive or have adverse effects on the player's well-being. Examples are eyestrain, headaches, and even injuries in exergames).

Thus, there are interesting perspectives but also pitfalls in using serious games. Persons who like to either use or create a serious game face many difficult issues. How can a serious game be made enjoyable? How can it be motivating? How can it be engaging on an emotional level? What mechanisms can be used to adapt the game to an individual user? Which goals can be targeted with a serious game? To which degree does a serious game really achieve the intended goals? How does it compete successfully with other leisure time activities? What can expertise in pedagogy, psychology, computer science, art, design, economics, or social sciences contribute to the development of a serious game? How is a serious game produced? How does the development process differ from the production of an entertainment game? How costly is the production? In order to answer these questions, this textbook compiles insights from research, experiences from developing and using serious games, and many best practice examples. The aim of the book is to lay a solid foundation on top of which the reader can assess, create, use or research serious games.

1.3 Terminology

There are many terms associated with serious games. In this section, some of the basic terminology of serious games is introduced. Important terms are defined and explained to provide a common conceptual basis for all chapters of this book. Further terms that are relevant to serious games will be defined in subsequent chapters. Figure 1.1 provides an overview of the basic terms defined in this section.

The definition of the term *serious game* was already presented in Sect. 1.1. As has been mentioned there, the term should be clearly distinguished from the term *gamification*. Taken literally, the term gamification means "making a game of something that is not a game." According to Deterding et al. (2011), *gamification* is an "informal umbrella term for the use of video game elements in non-gaming systems to improve user experience (UX) and user engagement." In particular, game-based concepts and/or elements are used to "gamify" existing non-game applications. Typically, but not necessarily, this is less than a full serious game.

Games with a purpose (GWAP) can be considered as a kind of complement of the term *gamification*. The term *GWAP* denotes games deliberately designed to employ players in order to serve a particular non-game purpose (von Ahn 2006). Ideally, GWAP provide incentives for people to participate in efforts such as large-scale problem solving, picture tagging or finding appropriate textual description of images. GWAP are a motivating and attractive means to exploit the

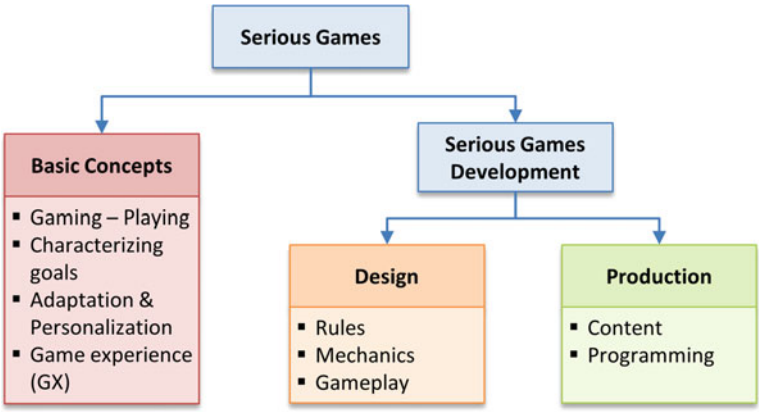

Fig. 1.1 Terminology of serious games—overview of basic terms

potentials of crowdsourcing or citizen science, e.g., (Quinn and Bederson 2011). In citizen science, for example, scientific problems are transformed into a comprehensive game to be solved by a community of non-scientists (Hand 2010). Successful examples are *Galaxy Zoo* (Raddick et al. 2010, 2013), *Foldit* (Khatib et al. 2011; Cooper et al. 2010), and *Phylo* (Kawrykow et al. 2012).

> *Gamification* means to add game elements to a non-game area, whereas *games with a purpose* denote games designed to exploit crowdsourcing in order to achieve a non-game purpose.

In order to distinguish other digital games from serious games, we introduce the term *entertainment game*.

> An *entertainment game* is a digital game that has exclusively the goal to entertain the player. A digital game is either an entertainment game or a serious game.

Figure 1.2 shows that terminology in serious games is concerned not only with serious games themselves, but also with their basic concepts. Here, two activities have to be distinguished on a fundamental level: Play(ing) and Gaming.

- According to George Herbert Mead, a well-known philosopher and social psychologist, *play* is an activity in human development where a child imitates the roles of others in the sense of role playing (Mead 2009). In a broader sense, playing means a *purposeless, intrinsically motivated activity with no explicit rules*

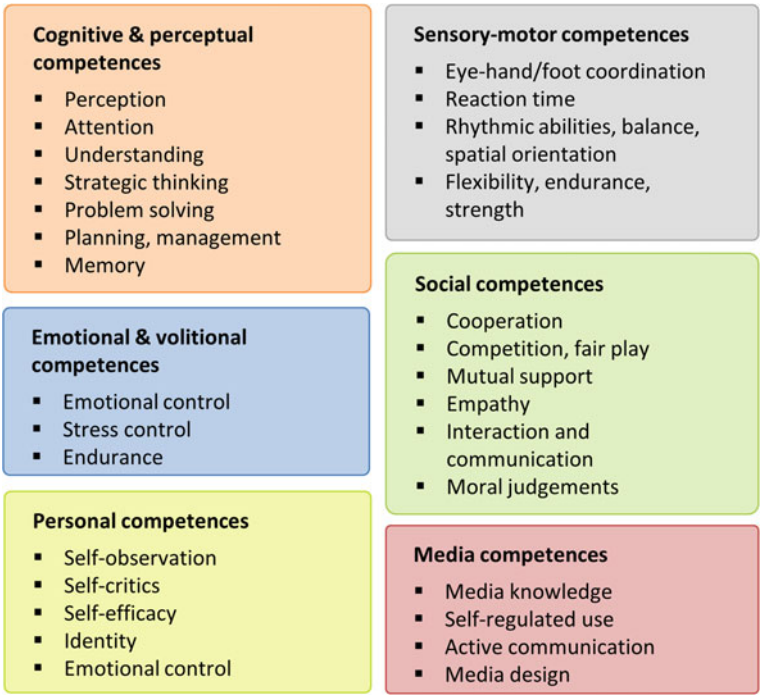

Fig. 1.2 Six examples of competence domains specifying the characterizing goals of serious games according to Wiemeyer and Hardy (2013)

(as opposed to gaming). Rather, the activity of playing emerges and progresses according to the implicit dynamic interaction of the players and the situation. For example, players may change a game feature and watch what happens; based on the result they may change the game feature again to experience the effect. This cycle may continue, without being determined by explicit rules.

- *Gaming* (as the second stage of identity development) is an organized rule-based group-play with structured roles (Mead 2009). Again, in a broader sense, gaming can be considered a *purposeless, intrinsically motivated activity according to explicit rules*. Examples would be to play basketball or table tennis. In these games, certain rules—i.e., passing, serving and returning of the ball—determine players' activities.

Playing is a purposeless, intrinsically motivated human activity without explicit rules, whereas *gaming* is a purposeless, intrinsically-motivated human activity based on explicit rules.

As mentioned above, another basic concept of a serious game is its characterizing goal. It is important, as it characterizes the serious game and can be used to classify serious games into several categories. The characterizing goal can pertain to several competence or skill domains, e.g., Wiemeyer and Kliem (2012) or Wiemeyer and Hardy (2013):

- Cognitive and perceptual competences/skills
- Emotional and volitional competences/skills
- Sensory-motor competences/skills
- Personal competences/skills
- Social competences/skills
- Media competences/skills

Figure 1.2 illustrates examples for these competence domains.

The characterizing goals of serious games can be matched to *competence domains*, e.g., cognition and perception, emotion and volition, sensory-motor control, personal characteristics, social attitudes, and media use.

Serious games can be classified according to various competence domains. It is less common to distinguish serious games based on their target group within specific application contexts. One example is a *corporate game* that is targeted at the employees of a company. Sometimes, there is a distinction made between serious games for (formal) education and serious games for (informal) training and simulation, as it is assumed that they cater to different target groups and application contexts, respectively (e.g., university students vs. company employees).

Educational games denote a subgroup of serious games, tackling the formal educational sector from elementary schools to higher education, vocational training, and collaborative workplace training. Whereas *learning games* address primarily informal learning, *educational games* focus on formal learning in dedicated educational institutions.

Besides the characterizing goal, the competence domain, and the target group, serious games can be categorized by application area. According to the *Serious Game Classification System* provided by Ludoscience (2014) or the serious games directory provided by the Serious Games Association (2014), among the most common serious games categories are corporate games for training and simulation purposes, educational games, health games, and advergames. Further categories include social awareness games, games for architecture and planning, and games for tourism and cultural heritage. Training and simulation represent a large application area for serious games that is also commercially relevant. Popular examples

are numerous flight simulators. Other examples are *TechForce*, a game-based training and learning environment for trainees in the field of electro and metal industries, or game modifications of the popular entertainment games *Civilization* or *Oblivion* that are employed to teach history or geography in higher education. Due to increasing demands on the health system, *health games* have become more and more popular. These games address several health-related aspects such as nutrition and physical activity. To support therapy, numerous *rehab games* have been developed, e.g., in neurorehabilitation (Wiemeyer 2014). The genre of *persuasive and public/social awareness games* tackles issues such as energy, e.g., *EnerCities* (Enercities consortium 2014), climate, e.g., *Imagine Earth* (Serious Brothers GbR 2014), security awareness games, e.g., quiz-based games such as *ID Theft Faceoff* from OnGuardOnline (Johnson 2014), and religion, e.g., *Global Conflicts: Palestine* (Serious Games Interactive 2014).

Adaptation and personalization are basic concepts of serious games (see Fig. 1.2). Entertainment games as well as serious games are usually played by a wide variety of players having quite different characteristics. Furthermore, players show more or less progress in the competences mentioned above during and after playing. Therefore, one of the most important requirements for good games is to fit as closely as possible to the characteristics of the player in order to be both attractive and effective. This means that the game should be *adaptive and adaptable* to the personal characteristics of the player as well as to the requirements for reaching the characterizing goal. There are many options to ensure adaptability—from designing one's own avatar to choosing an appropriate game level. On the other hand, adaptivity means that the game adapts itself more or less automatically to the specific situation. There are also many options for adaptivity, for example, presenting easier or more difficult tasks, providing support (e.g., hints to the solution), or switching to a new scenario. For adaptivity to be effective, a valid *in-game assessment* of relevant aspects like emotional or cognitive state of the player or emerging difficulties is required. Kickmeier-Rust et al. (2011) introduced the concepts of micro and macro adaptation. *Micro adaptation* is a specific fine tuning *whereas macro adaptation* comprises traditional techniques such as adaptive presentation, navigation, curriculum sequencing, and problem solving support based on static learner characteristics. Due to the challenge that game adaptation must not compromise gaming experience, a dynamic in-game (or "stealth") real-time assessment of cognitive, perceptual-motor, emotional, and motivational states is indispensable in order to provide appropriate non-disruptive micro adaptations, i.e., non-invasive adaptations like adaptive hinting, adaptive feedback, or an adaptive adjustment of the environment.

Personalization means that games can be tailored to the individual characteristics of the playing person. The game can be either adapted by an external person like the player, teacher, or therapist (*adaptability*) or adapt itself based on in-game assessment (*adaptivity*).

Due to their dual mission, serious games have to be both attractive and effective: They have to achieve the characterizing goal without compromising game experience. Therefore, the term *game experience* (GX) is central to the claim of serious games to elicit experiences that are characteristic for games. GX denotes complex and dynamic psychic phenomena while playing games. The concept of GX includes several dimensions like fun, challenge, flow, immersion, presence, tension, positive and negative emotions, curiosity, fantasy, self-efficacy, and motivation. GX can be measured at three levels: behavior, physiology, and subjective experience.

> *Game experience* (GX) is a subjective experience of "true gaming," having fun, being challenged, being immersed and involved in the game, feeling emotions, and being absorbed by the game. The concept of GX can be subdivided into numerous dimensions. One of the most important dimensions is *game flow*.

Game flow is another basic concept. Game flow is an experience during gaming characterized by exclusive concentration on the game, feeling control over the game, being immersed in the game, facing clear goals and getting immediate and consistent feedback, e.g., Sweetser and Wyeth (2005). Game flow occurs when there is an appropriate fit of task difficulty and player skills. Sinclair (2011) introduces the concept of *dual flow*, i.e., a balance of attractiveness and effectiveness. Figure 1.3 illustrates the idea to influence both attractiveness (i.e., good GX) and effectiveness (i.e., achievement of the characterizing goal) by establishing and maintaining an appropriate balance of task difficulty and skill level.

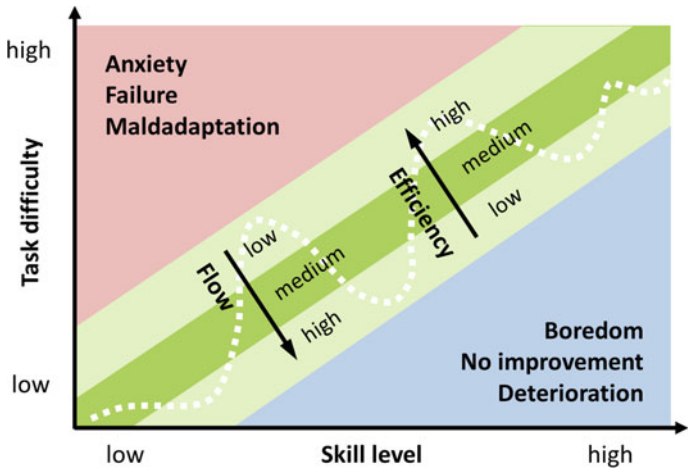

Fig. 1.3 Dual flow as a balance of task difficulty and skill level

The concept of *dual flow* is characteristic of, and unique to, serious games. The appropriate balance of task difficulty and skill level ensures that the double mission of serious games is accomplished: being both effective and attractive.

As depicted in Fig. 1.1, a second major branch in the terminology of serious games is concerned with serious games development.

Serious games development consists of two main components: game design and game production. *Game design* comprises all aspects relevant to the internal structure and external appearance of a game, whereas *game production* comprises all aspects of building the game.

Game mechanics, gameplay, and rules are important aspects of game design. These elements are explained in the following.

Game mechanics denotes "methods invoked by agents for interacting with the game world" (Sicart 2008). In other words, game mechanics signifies the ways to interact with a game according to the implemented rules and the specific situation, i.e., a scenario or game level. Examples include jumping on platforms or hitting a ball.

Gameplay is a term that is very similar to game mechanics. In a narrow sense, game mechanics denotes the internal management of interactions, whereas gameplay denotes the external process that develops between the player and the game while the game is played. Examples are controlling the dancing movements of an avatar by waving the arms or eliciting jumps by pressing a button.

Rules are regulations or settings constraining the game. Rules can contain regulations about what is allowed and not allowed. Rules typically have the shape of *if-then relations* (sometimes only evaluated when a certain *event* occurs). This means that if certain preconditions are fulfilled then a specific consequence will take place. For example, if the player moves too fast, the avatar may start running.

Game mechanics denotes the way the players can interact with the game. It focuses on the internal management of interactions, whereas *gameplay* denotes the external appearance of interactions. *Rules* are regulations and settings constraining the game. They typically take the form of if-then relations.

Moreover, game design covers 2D images, 3D models, sound, music, art, avatars, the behavior description of non-playing characters (NPCs), and level design. All tangible or perceivable elements of a game, including their appearance and

behavior (e.g., images, textures, 3D models, sounds, scripts), are called *game assets*. The game design is specified in a *game design document*. For the design of serious games, the entertainment part has to be combined with the characterizing goals of the serious part. In other words, game design principles need to match the requirements and characterizing goals of a serious game. This starts with the game idea and ends with the production of appropriate game assets fitting to the nature of a serious game application domain and the targeted user groups.

As mentioned above, game production is the implementation of game design, i.e., the building of the game. Two important components of game production are *asset production* (also called *content production*) and *game programming*. To actually produce a serious game, methods, concepts, and technologies are used analogous to the development of entertainment games. However, these concepts, technologies, and principles are enhanced with further information and communication technologies (ICT) as well as domain-specific methodologies and technologies with regard to the characterizing goals of the serious game. These are applied in different application domains of serious games (see Sect. 1.5).

Game production comprises content production and game programming. *Content and assets* are produced combining domain-specific knowledge and game technology. *Game programming* denotes adequate hardware and software arrangements including sensors, interfaces and multimedia components as well as relevant algorithms and programming concepts.

1.4 A Reference Scenario for Serious Games

What does the lifecycle of a serious game look like? What are the typical steps and phases that are encountered from the wish to have a serious game to players actually playing it? Who participates in this process? Who are the stakeholders? In this section, we provide a prototypical reference scenario and illustrate it with two application examples: (1) development and deployment of a serious game for corporate training—initiated and financed by a corporation, and (2) a game-based mobile guide for the elderly to access cultural heritage—initiated and financed as a publicly funded research project.

The lifecycle of a serious game begins with a *preparation phase*, followed by a *development phase* (with a number of iterations) and a *deployment phase*, as shown in Fig. 1.4. Similar to book editions, the overall process might be restarted again (and again), resulting in several editions of the serious game. Reasons for that might include new research and technology achievements, as well as an extended spectrum of targeted user groups or further developments in the application domain. For instance, improved domain knowledge with new therapeutic approaches or new sensor technologies might lead to improved game design concepts. With respect to

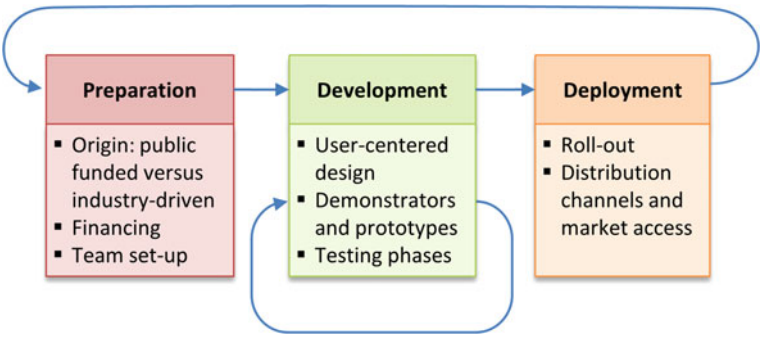

Fig. 1.4 Lifecycle and iterations of a serious game—preparation phase, user-centered iterative development phases and deployment phase

the extension of targeted user groups, corporate training environments might not only address employees of the company, but also applicants for recruiting programs. Similarly, a game-based mobile guide originally planned for the elderly might be also adopted for younger users, providing slightly modified user interfaces and age-appropriate interaction principles.

The preparation phase is the first step towards the development and introduction of a serious game, and initializes the lifecycle of a serious game (see Fig. 1.4). As outlined in Sect. 1.2, the basic motivation to create and introduce a serious game is usually the same. Serious games are seen as a promising mechanism or "tool" to fulfill a specific goal in the different application areas, e.g., serving as a corporate training instrument, or a mobile assistant for playful access to cultural heritage for the elderly. Although there is the common motivation to use a serious game as a tool to fulfill characterizing goals, this commonality does not extend to its origin, preparation, development, and deployment. In fact, those differ considerably in concrete application contexts. Whereas public awareness games, educational games, or cultural heritage games typically originate from and are financed in the context of publicly funded projects with an overall focus beyond serious games, the starting point in the commercial sector is often different.

In the case of publicly-funded projects, a serious game is often a byproduct. It is not the ultimate goal of the surrounding project, but serves as a showcase to demonstrate what the key objective of the funding scheme might be, for example, the working principles of new ICT mechanisms, new learning paradigms, or new concepts for ambient assisted living and mobility support for elderly people. On the other hand, in industry-driven serious games, typically decision makers of corporations look for a good solution for a concrete problem (e.g., all employees need to be trained for a new product or process), and they might have heard of the potential of serious games, e.g., as a training instrument. The reason for a decision maker to choose a serious game over other means might be that there are either no alternatives, or that the alternatives (e.g., classical eLearning solutions) are assumed to be less effective, less innovative, less promising, or too expensive.

In the second step of the preparation phase, the market for existing serious games is checked. However, in most cases there are no commercial off-the-shelf serious games available matching the concrete situation and particular needs of the company. Hence, the decision maker searches for appropriate serious game providers (i.e., game developer studios or other research and technical development (RTD) providers with profound knowledge of serious games development). In an optimal case, a game developer studio or RTD provider for serious games can reference similar solutions with related evaluation studies that have proved the effects of a serious game (both in terms of fun and user/game experience, and effects towards the characterizing goal). This also serves as an internal argument for the project initiator and decision maker for necessary investments. And this indicates one dilemma of serious games: Unfortunately, only a few reference examples with singular evaluation studies exist proving their benefit in dedicated application contexts. Therefore, the majority of serious game development projects are based on a trial and error strategy. Apart from pure economic or scientific considerations, many corporations are fully convinced of the potential of game-based mechanisms and serious games in principle. Being among the first in their field to use these innovative new media concepts, they strive to obtain a status as an early adopter. This is particularly true if they have digital natives or digital immigrants among their employees or customers (i.e., people who grew up being surrounded by or fascinated with digital games and highly interactive technologies).

The third step of the preparation phase includes the development team's composition, consisting of the customer side (management level and technical level) and the development side (game designer, game programmer, etc., see Sect. 1.5.6). In contrast to entertainment games, further domain experts (e.g., educators, psychologists, marketing experts) complement the development team. In our two examples, doctors, therapists, or subject matter experts for corporate training or personalized tourism need to be involved. Then the actual development can begin.

The development phase represents the main part of the overall development process of a serious game (in terms of development duration per edition, neglecting phases from one edition to another). It typically follows a *user-centered design* approach involving users (e.g., trainees or employees in the first application example, or elderly people in the second example) from the beginning. User involvement may even have already started in the preparation phase.

The development phase begins with gathering information about the characteristics, needs and interests of the target user group and of the customer such as a training department of a corporation. This is the basis for writing the game design document and functional requirements of a serious game. Simple paper mockups or tinkered devices might be developed in order to provide a first impression about the envisioned serious game scenario and practical outcomes to the end users.

Based on the first round of user feedback, a set of initial use cases is defined in collaboration with the customer, the development team, and the targeted end users. This step is extremely important with regard to goal-oriented evaluation studies. These studies will be carried out to prove both the effects and the benefit of serious games, both in concrete situations and application contexts in later stages of the

development process. Again, mockups or early technical demonstrators providing the principle functionality of the serious game are developed to receive valuable feedback from the end user side. Similar to classical software engineering processes, the game design document and functional requirements are then translated into game scenarios (including game environments and game content, e.g., game assets), gameplay, and technical specifications (including game mechanics). This process typically results in a prototype that provides full functionality of the serious game, which is tested in detail by a broader number of end users.

After taking user feedback into account, game production begins. This results in fully integrated prototypes of the serious game or specific parts—such as a game level for a thematic area in the corporate training scenario, or a sightseeing point for the mobile guide scenario. These prototypes are tested and evaluated within user studies following the use case scenarios. During this process, different software engineering methods are often used, ranging from classical methods, (e.g., the *waterfall model*) to more recent *agile software development methods* such as *SCRUM* (software engineering concepts will be described in more detail in Sect. 4.4). Agile methods focus on iterative development and improvement of smaller parts of a game with much shorter development cycles that are called *sprints*. This approach to software development is well known and widespread in the game development community. Sprints typically take only a few days up to some weeks—which is much less compared to classical software development projects following the waterfall model. For instance, in publicly funded research projects, two to three development cycles are common in a project of 3 years. As soon as a stable version accepted by the end users is available, the roll-out of the serious game begins.

The third major phase in the serious game lifecycle is the deployment phase. Here, the serious game is rolled out to as many end users as possible from the target user group. In our two application examples, this includes all employees who need to take corporate training, or all elderly people who are visiting a city and might be interested in a game-based mobile guide to playfully explore it. The corporate scenario rollout is much easier, since employees are accessible via traditional hierarchies and can be easily reached via a corporate intranet. Furthermore, corporate training is usually free for employees, so there are no obstacles caused by cost issues. For the second example, the mobile city might be offered for free via a web portal from the city's marketing agencies or associations of elderly people. The practical question is how to access the market and reach as many customers a possible. Distribution platforms and channels such as *Steam* (Steam 2014) that are widespread in both the entertainment games industry and in the gamer communities seem to be inappropriate for serious games. Also, the principle of cross-platform publishing of entertainment games (on different game consoles or as PC, browser or mobile versions) is not widespread for serious games yet.

The introduction of a serious game into existing corporate processes typically takes at least 6 months. Depending on the complexity of the content, it may take up to a year, or even more. This duration is comparable with the introduction of a Web-based training module when eLearning was introduced.

From an economics perspective, a challenge for both commercial and publicly funded projects is the limited development budget for serious games, especially compared to the budgets available for entertainment games. This may lead to a discrepancy between the expectations of the end users and the necessary budgets to create a convincing, successful serious game that is both entertaining and fulfilling its characterizing goal. Especially members of the generation born after the mid 1980s, sometimes called "digital natives," who are familiar with entertainment games providing a convincing gameplay, excellent graphics, etc. have similarly high expectations for serious games even in case they are aware that these serious games have a lower budget. This problem of a limited development budget is most apparent when it comes to the conceptualization and production of personalized, adaptive serious games. In contrast to entertainment games created for the mass market, the primary goal for the field of serious games is to provide adaptive games that match the characteristics and needs of individual users or smaller user groups. The particular requirements for the development of personalized, adaptive serious games will be described in Chap. 7. Compared to traditional learning and training systems such as classical Web-based training or eLearning arrangements, the cost of digital games are much higher. This often causes wrong assumptions and expectations by end users who expect to get high-end games for a similar budget as traditional eLearning arrangements.

1.5 Overview of the Development Process of Serious Games

There are established development processes for digital games described in the literature, e.g., in Rabin (2009). These processes were developed with entertainment games in mind. The development process of serious games, however, is not identical to the one for entertainment games. In serious games, there are one or more specialists from an application area involved. For instance, a health game needs medical and health-related competence right from the beginning. A second example is an educational game about the nourishment for babies requiring pediatricians, behavioral scientists and experts in the field of didactics. One or more of the application area specialists may provide an application-specific game behavior. For example, a didactic expert might introduce didactic elements into the game.

Figure 1.5 shows a framework for the development of serious games. In the center, game design methods, concepts and principles are used in analogy to the development and design of entertainment games. These concepts, technologies and principles are supported by further information and communication technologies (ICT) as well as domain-specific methodologies and technologies with regard to the characterizing goal of the serious game) Typical ICT technologies include mechanisms of artificial intelligence (AI) for the planning, automated generation and intelligent behavior of virtual characters, aspects of human-computer interaction (HCI), usability features, usage of game controllers and I/O devices, multimedia aspects (computer graphics, audio, etc.) as well as sensor technology to retrieve and

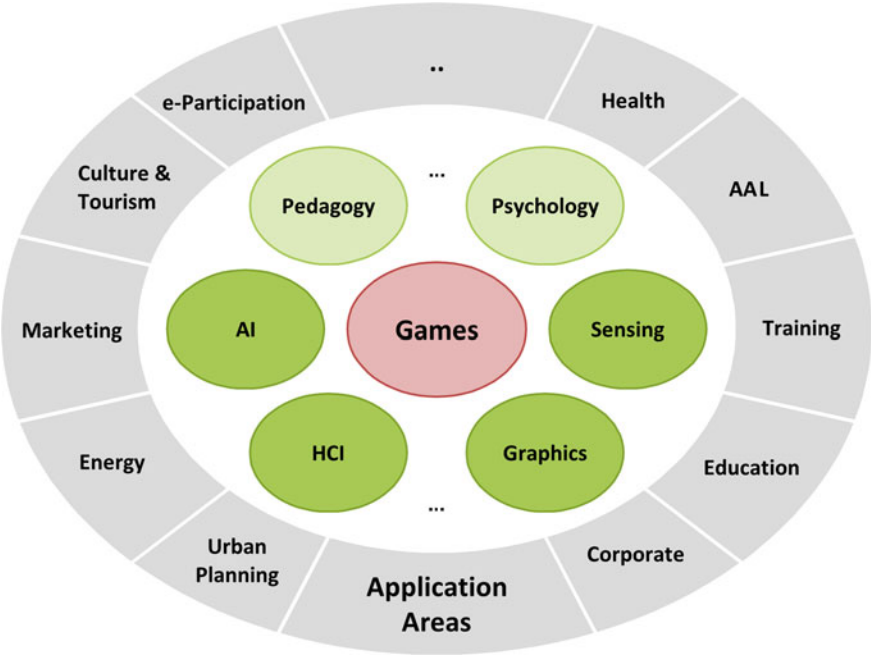

Fig. 1.5 Serious games—game design combined with further concepts, technologies and disciplines, applied in a broad range of application domains

monitor context information. Domain-specific methodologies include aspects such as psychosocial, didactic, and pedagogic concepts for educational settings, ranging from kindergarten to collaborative workplace training, or psychophysiological mechanisms to monitor the vital status in healthcare applications.

In the following, we briefly introduce key aspects of the game development process: game idea and game design, game architecture and game production, game adaptation mechanisms, game platforms, game engines, and the game development team.

1.5.1 Game Idea and Game Design

At the heart of a good game design is always a creative team and a good game idea. The better the idea, the more fun the game is usually to play, and the more useful it might be for achieving the goal to entertain and to reach the characterizing goals. A creative atmosphere in the development company is helpful for good game design (Fullerton 2008). Creativity can also be stimulated using creativity techniques, books (e.g., Csikszentmihalyi 2009), and seminars.

A game idea that is developed from scratch is rare. As no model exists to predict how well a game idea will be received by the intended audience, the use of best

practices is fundamental. Thus, game designers often rely on previous experiences. They often analyze existing games and stick to working formulas, reducing the risk of a game being a failure. This is also a reason why sequels of successful games are common. One problem with serious games is that not as much experience has been gathered as with entertainment games.

A fundamental task of game design is to create the game experience. However, game experience cannot be designed directly but only indirectly by specifying game rules, game mechanics, and other features of the game (e.g., the design of game assets). The game experience emerges from these design choices. In serious games, the game designers also have to take into account that the players not only have a positive game experience but that the characterizing goals are met. As there can be a tradeoff between achieving all these goals, game designers need to compromise. In order to achieve this, there needs to be a close cooperation of the area specialists with the game designers and game engineers. Often, creative ideas come from both sides. The area specialists might have plenty of initial ideas that they would like to see in the game, the engineers have to find ways how to implement them. Gradually both game designers and game engineers learn more and more about the characterizing goal. This allows them to have their own implementable, creative ideas (Ritterfeld et al. 2009). On the other hand, the area specialists gradually understand what is feasible in software, and that steers their ideas into the right direction.

As described above, a basic approach of game designers is to work iteratively. Initial choices are tested. Then these test results are analyzed, and modifications to the game are made. This is repeated in order to fine-tune the game design. An example is the balancing of the game rules. If the game emerging from the initial rules is too difficult, the players will become frustrated. If it is too easy the players will be bored (see Fig. 1.3). A good approach is thus that the game designers start with an initial set of rules, test the emerging game and use the test results for modifying the rules.

To complicate matters, the players change when playing the game: they become more experienced and hone their skills. Thus, game designers need to design a mechanism that maintains the challenge for the player at the right level. In his landmark paper, Csikszentmihalyi (1990) describes a diagonal corridor in a two-dimensional graph, where the players should find themselves; the two dimensions are the degree of difficulty of the game and the level of skill of the players (see Fig. 1.4 for a version adapted to serious games). For achieving this, the game designers have several game design methods, for instance, the concept of *levels*. Novice players start at level 0 where they have to accomplish simple tasks. When they do that well, the players are elevated to higher levels where the tasks become more difficult.

Another task for the game designers is to motivate players to continue playing. Motivating aspects are of particular importance in serious games. Game designers can also use several game design methods for this. One method is again to use levels and motivate players by giving them a sense of progress or by making them curious about the next levels. Another game design concept is *in-game awards*. A player who has accomplished a task gets awarded an in-game bonus. In the

simplest case, this bonus consists of points, and a ranked list of the players with their points is displayed when the game is over. This might motivate players to try their best to end up high on that *high-score list*. Other awards can consist of more powerful weapons, desirable objects or additional lives for the player. In serious games, those awards could refer to the purpose of the game.

1.5.2 Game Architecture and Game Production

The game design describes a serious game on a conceptual level. In order to be playable as a digital game, the game design needs to be implemented in a software system. This is the task of the game production. Beside software development, the game production also comprises the creation of the game assets (e.g., generating 3D models of game objects, animating game characters, drawing textures, or recording a soundtrack).

Developing a game software system can be challenging task, as these systems can be highly complex. *Divide et impera*, i.e., breaking down a complex problem into smaller problems, is a software design paradigm that has been successfully employed in the past to deal with complexity. Thus, to make the production task manageable, the game software system is often broken down into subsystems. A *game architecture* describes which subsystems are present in a game and how they are assembled to form the entire digital game. The architecture of a game is depicted in Fig. 1.6.

The game architecture is structured into many components interacting with each other. The *hardware* layer can be a PC, smartphone, game console, etc. As usual in any computer system, we have the *operating system* on top of the hardware. On general-purpose computers, such as PCs or smartphones, it supports many applications in parallel. In contrast, on game consoles, it is tailored to enable gaming efficiently.

On top of the operating system comes the game runtime environment. It is based on a *platform independence* layer that shields the *core* of the game engine from the details of the operating system so that it can run on many different hardware platforms. At the heart of the core is the *main loop*. Here, a timer controls the execution of all those components that require periodic updating; examples include the game's artificial intelligence (AI), the physics (e.g., simulation of gravity), collision detection and many more. If the game has a multiplayer mode, the *multiplayer management* component allows connecting to other players, typically via a central server, and often game mastering is also supported. A *resource manager* maintains the *asset database* of the game, including materials and textures, fonts, the skeletons of avatars, and sounds. In contrast to the assets, the *game data manager* stores information about the state of the game and the players, e.g., the points they currently have and the level at which they last played. As its name says the *output generator* creates the visual output for the display and the audible output for the speakers or earphones; sometimes haptic output is also provided, for example, force feedback on a steering wheel. And the *input handler* deals with all

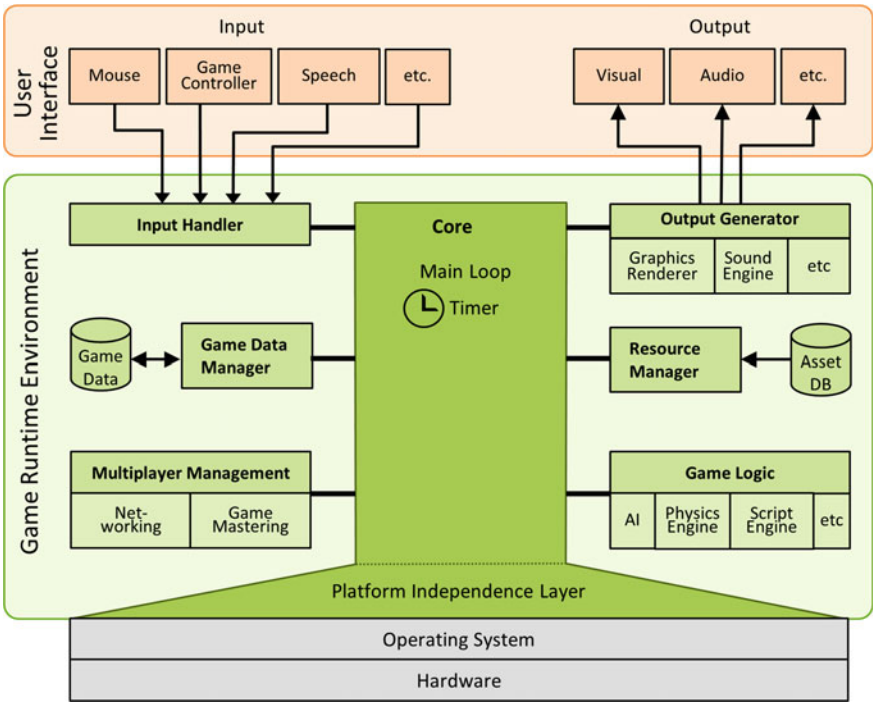

Fig. 1.6 The architecture of a game at runtime

kinds of user input, such as mouse input, game controller input, camera input from a Kinect device or speech input. The game architecture is simplified here; more details will be discussed in Chap. 6 on game engines.

The game architecture of multiplayer games is more complicated than that of single-player games. There are two main reasons for that. First, the network causes a delay for the communicated actions of the players, causing temporal inconsistencies. Second, the global common state of the game must be maintained somewhere. Although several research papers were written propagating peer-to-peer games without a central server (Hu and Liao 2006; Bharambe et al. 2008; Lehn et al. 2011) experience shows that a central server is the most reasonable solution to run a multiplayer game efficiently: the players are connected to that server, the server receives action messages from them and reflects those in the centrally maintained global state. Updates to that state are then periodically forwarded to the machines of the players. Inconsistencies are still possible. For example, when two networked players shoot at each other within a short time period (say, 100 ms), both expect the other player getting killed because they do not see him shoot in time. The game server has to resolve that inconsistency, deciding which player was quicker than the other. The two local displays at the players are then updated to reflect that new global state. As a result, the game architecture is not only concerned

with the game software running on a single computer but needs to reflect a game software system that contains the software run by the individual players and the game server.

1.5.3 Game Adaptation Mechanisms

A serious game always pursues the target to change the player with regard to the characterizing goal. This is usually the reason why a player chooses to play a serious game or why a player is asked to play it, e.g., by an employer or a teacher. If the serious game is successful, there is a discernible difference between the individual player before and after playing the game. Differences could be that the player possesses novel skills or knowledge, the player has different attitudes or opinions, or the player is healthier. Thus, in order to be successful, a serious game needs to adapt itself even more to an individual player than an entertainment game that does not seek to change the player but just to entertain.

There is another reason to emphasize personalization and adaptation in serious games. Serious games typically address a much smaller and more targeted audience compared to entertainment games. Examples include employees of a corporation or users with a specific health characteristic in the context of health games. In contrast, entertainment games are produced for a broader user group, e.g., the community of hardcore gamers in general or player communities for a specific game or game genre.

Hence, the aim of personalized, adaptive serious games is to match the individual needs and characteristics of a small user group as well as possible. This adaptation must happen automatically, without manual intervention. Figure 1.7 provides a conceptual model for the development and control of adaptive serious games. The model consists of four major components and four phases: First, within the sensing phase, the current player behavior is collected and recorded via sensing technology. This ranges from simple logging of game events and contextual information about the setting, time and place to the measurement of psychophysiological data of users during the play. In a second phase, this information is aggregated and stored in a knowledge base. There, the dynamically acquired, user-centered data is combined and aligned with the static information, such as the user profile, domain model (e.g., training programs for health games), or game patterns and interaction templates. The analysis and interpretation might take place either automatically (i.e., algorithmically according to predefined rules), in real-time during play, or manually by subject matter experts such as doctors, therapists or sport scientists familiar with cardio training programs. The results of the analysis and interpretation phase are the input parameters for the adaptation component. For instance, in the application context of a cardio training game, a very high heart rate of the player triggers a rule to reduce the resistance of an ergometer. Further adaptation concepts include an automatic content creation and difficulty adaptation for individual users as well as adaptation rules for the gameplay. For example, the training intensity might be varied by a higher or lower frequency of appearance of

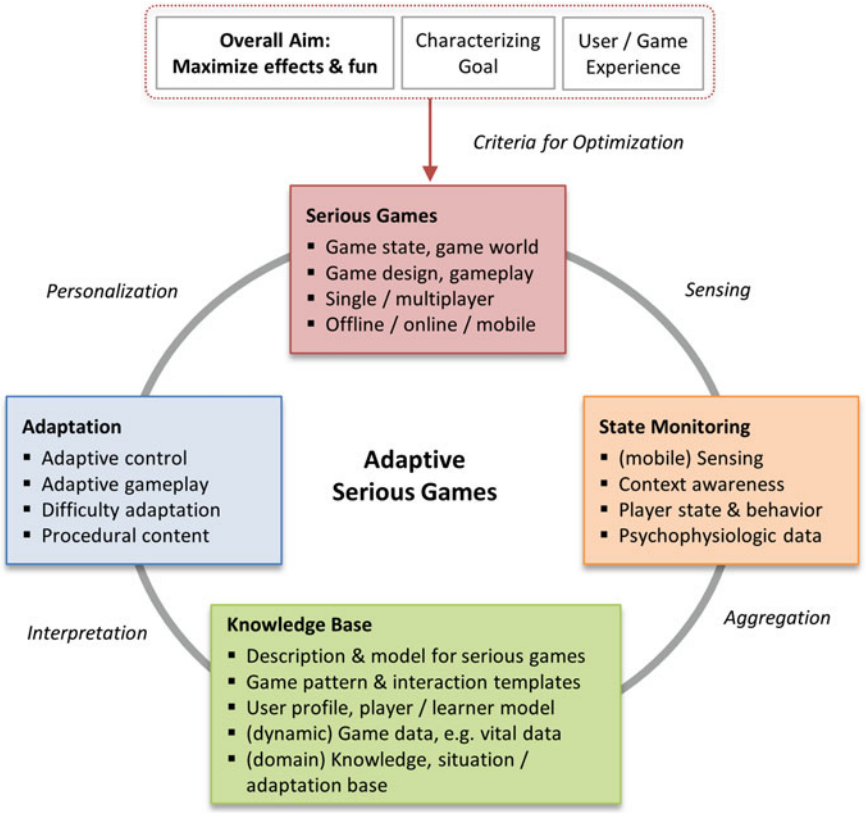

Fig. 1.7 A pattern for adaptation in serious games

objects to be collected by the player. Finally, in the personalization phase, the result of the adaptation process is presented to the player. More details about the underlying concepts of the adaptation and personalization process for serious games will be presented in Chap. 7.

1.5.4 Game Platforms

Game software alone is not sufficient to play a game. We also need hardware that runs the software. The hardware comprises processors, graphics hardware, memory, storage, input devices (e.g., a keyboard or specific game controllers), and output devices (e.g., a smartphone display or loudspeakers). This hardware together with basic software (e.g., device drivers or an operating system such as iOS or Microsoft Windows) forms a platform supporting the game software. Nowadays, we have many game platforms to choose from: a standard PC, a game console connected to a TV set, a mobile game device, and a smart phone are just examples. Each platform

has typical characteristics. For example, compared to a high-end PC, a smartphone is mobile and has more sensors that can be integrated into a game (e.g., GPS, touchscreen, acceleration sensors)—but it also has a very small screen and inferior graphics performance. While some platforms such as tablets or PCs are multipurpose, other platforms are geared towards gaming or only support games (e.g., a Nintendo 3DS).

A special gaming platform is the World Wide Web. With the software of the Web browser and standardized content descriptions such as HTML, an additional layer of abstraction is put above the hardware layer. This allows abstracting from different peculiarities of the underlying hardware. Digital games in general that use the Web as their gaming platform are called *browser games*. They are especially attractive for marketing applications where ease of deployment and no cost for the user are important arguments.

1.5.5 Game Authoring Environment

Game software is often not developed from scratch; either an existing game software is modified, or a game authoring environment is used. Since many mechanisms exist in much the same ways in many games, it makes sense to develop generic software for their support. Game authoring software that helps the game developer is illustrated in Fig. 1.8. Its main part is the game engine.

The most important component of an authoring environment is the *game runtime environment*. Its architecture has already been shown in Fig. 1.6.

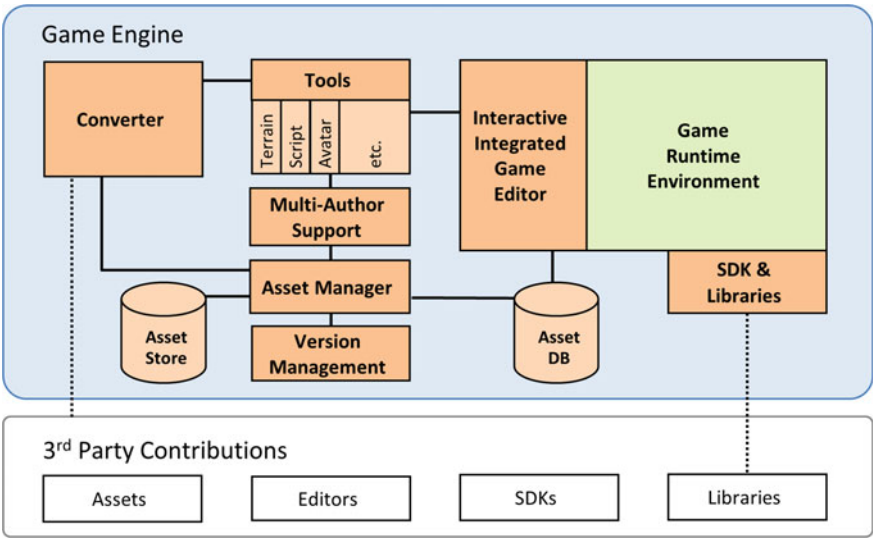

Fig. 1.8 Game engine and game authoring environment

When a game is developed, the game developers have prefabricated assets at their disposition from an *asset store*, managed by the *asset manager*. It is possible to fill the asset database for the game runtime environment either by importing assets via the asset manager from the asset store, or by creating assets with editors or third-party tools. In order to be usable within the game engine, converters are necessary to import and export data. Authoring tools provided by the game engine usually allow editing terrains, levels, game scripts, avatars, materials, textures, etc. In some game engines, there is an *integrated interactive game editor* that offers sophisticated editing capabilities, which makes it feasible to assemble the game from the assets, define the game logic, etc. Often, this editor allows the game to run while editing is in progress.

In addition, the game engine offers a *version control subsystem* for different versions of the game, *performance analysis tools* for optimizing the game, and *support for multiple authors* working in parallel. It may also provide a *software development toolkit* (SDK) that allows extending the pre-fabricated functionality of the tools or the runtime environment. Game engines can also be open source, or they can offer a set of software libraries in different programming languages that can serve as a foundation for a customized game software development. Likewise, third-party software libraries can be used to alter a game engine (e.g., integrating or replacing a physics engine), and other 3rd party tools may offer SDKs to customize them and integrate them better into the authoring workflow.

A large number of proprietary game engines exist, which have been developed by game companies. Almost all the big game studios have their own: Some are commercially available, e.g., Unity (Unity3d 2014), and others are in the public domain, e.g., OGRE 3D—Object-oriented Graphics Rendering Engine (OGRE 2014). In recent years, the licensing policy for game runtime environments has changed. Today, inexpensive or even free versions are available in order to get game developers or small game companies hooked to a specific product. Usually, these inexpensive versions do not offer full functionality, but can be upgraded for an additional fee. They are especially popular in both academic environments and with casual developers of smartphone games. For example, based on this licensing model, the Unity 3D game engine has won more than 3.3 million users by 2014. In this book, Chap. 6 is devoted to game engines.

1.5.6 The Game Development Team

A typical game development team consists of several persons with different skills and different duties who are not necessarily involved during all phases of game development. Key roles are game designer, game engineer/game programmer, artist, quality assurance experts and expert for the serious part.

Game designers are the heart of the game; their ideas determine the success of the game, both in terms of the fun while playing and of the characteristic (serious) component. Game designers can work at different levels: at the basic level, the goal and the levels of the game are designed. At an intermediate level, specific areas in

the game world or specific levels of the game are designed. At the detailed level, game rules are fine-tuned. In larger teams, a *game design manager* ensures that game designers work together in a consistent manner.

Game engineers (sometimes called *game programmers*) are responsible for software development. They are often computer scientists, and they design and implement the game software. Some development studios distinguish between tool developers writing game engine software, with game programmers writing the game-specific code, and game engineers who are responsible for the software engineering process.

Artists are responsible for the artwork; they design the landscape, the objects in the game, and the avatars. The audio components are often designed by *sound artists*.

QA experts are responsible for the quality assurance of the game. They not only test the game software for its software quality (e.g., its robustness or performance), but also they conduct user tests to assess the game experience and the degree to which the characterizing goals are reached. The QA experts recruit test players and organize play tests.

Experts for the characterizing goal (also called *area specialists*) contribute knowledge that is essential to achieve the serious goal. For example, if the game is for medical rehabilitation, the experts must have a medical background.

Sometimes there exist additional roles, e.g., the *IT support engineer* responsible for the technical infrastructure (such as backups and software maintenance), the *project manager* responsible for organizing and running the development project, the *project controller* responsible for monitoring the projects' finances, the *producer* responsible for providing the resources for production (in particular the financial resources), and the *customer* responsible for specifying the characterizing goals. Key roles in the development process can be supported by secretaries or assistants.

1.6 A Short History of Serious Games

An introduction to serious games would not be complete without taking a look at their history. Although it is possible to also consider classic (non-electronic) games that have a serious purpose, we focus here on the history of digital games.

Early work on serious games was done in the US military. For example, Abt (1970) describes a game for training officers developed as early as 1961. The term became really popular with two events in 2002: Sawyer and Rejetski (2002) published their white paper *Serious Games: Improving Public Policy through Game-based Learning and Simulation*, and the game *America's Army* appeared in the market (Knight 2002). The latter is a military game engaging the player in realistic combat situations. It was developed by the US army in order to support the recruiting of young people. It features realistic weapons, and the players are dressed in uniforms of US infantry soldiers. The most successful players get an invitation letter from the recruitment office of the army. Actually, as early as in the 1960s, the

US military maintained an agency called "Joint War Games Agency" dedicated to the development of games for military purposes (Djaouti et al. 2011).

The earliest electronic game console for use in private homes, the Magnavox Odyssey, was shipped with both entertainment games and serious games. Its creator, Ralph Baer, had worked on it since 1966; he believed in serious applications of gaming (Baer 2005). The console came out in the US market in 1972. Since microprocessors were still in an early stage in those days, the console had specialized transistor circuits, and its display was an array of white lamps. Ever since, progress in digital electronics was reflected in both entertainment games and serious games.

In the 1980s, entertainment games were often played in arcades but those were not the right places for serious games. In contrast, in the home markets with PC games and video consoles, they slowly established their share. For example, exercise games were available in the 80s for the Atari 2600 and the Nintendo NES. They became really popular in 2006 with the arrival of the Wii (Nintendo 2008) which had a specialized interaction device, the Wii Remote Controller. It is a handheld pointing device, also containing a 3D acceleration sensor. A balance board is also available. They communicate with the main console via Bluetooth.

The next step in innovation came with Microsoft's Kinect in 2010 where the human body is used as the main interaction device. The console comes with a camera and infrared depth sensor detecting the joints of the human body in real-time. This kind of interaction is great for exercising; the Kinect is even used by US schools for dance training.

Whereas between two and 40 new serious games appeared per year from 1980–1990, that number increased to between 60 and 80 between 1990 and 2002. In the following years, between 70 and 240 serious games came out per year, with a significant increase after 2007 (Djaouti et al. 2011).

The main markets for serious games are North America, Japan, South Korea, and Europe. Whereas children were seen as the main players in the US, Japan, and Europe also had adults in mind. For example, *Dr. Kawashima's Brain Training* was a popular Nintendo health game in Japan. A European specialty is serious games for art and culture, with a goal to increase knowledge about cultural heritage in European countries. Examples include *Versailles 1685* and *Vikings* (Djaouti et al. 2011).

For a fairly complete overview of the current list of Serious Games, refer to http://serious.gameclassification.com/, where more than 3000 serious games are listed (Ludoscience 2014).

1.7 How to Use This Book

We conclude this introductory chapter with concrete advice on how to use this book in different contexts. Everybody is advised to read the introduction (Chap. 1) first; all other chapters assume that you have read the introduction beforehand. In particular, it is assumed that you are familiar with the terminology introduced in

Sect. 1.3 and have an overview of the concepts presented in the introduction. Otherwise, there are no more dependencies between the chapters. Thus, this book is highly modular, as you can select chapters in the order that is suitable for you. It is not required to read the book from start to finish. Each chapter is self-contained. To ease orientation, each chapter (except Chap. 12) adheres to the same basic structure. It starts with an abstract and an overview. At the end of each chapter, there is a summary and questions section to allow one to assess understanding of the material. The questions can also help to prepare for exams. This is followed by recommendations for further reading. It includes an overview of scientific journals and conferences that are relevant for the topics discussed in the chapter. Literature references conclude each chapter.

1.7.1 Organization of the Book

The basic chapter of the book is the introduction. All other chapters are clustered into four parts. The first part is concerned with the creation of serious games. This comprises the design of serious games (Chap. 3), authoring processes and tools (Chap. 4), and the content of serious games and its production (Chap. 5). The whole authoring process is an interdisciplinary effort requiring skills in areas such as computer science, art and design, psychology, didactics, and storytelling. The basics that are fundamental for interdisciplinary collaboration are laid in Chap. 2.

The second part focuses on the phase when the finished serious game is played. Important aspects are game engines (Chap. 6) that are the backbone during runtime. Peculiar for serious games is the need for personalization and adaptation; Chap. 7 deals with adaptation mechanisms, game balancing, and dramaturgy. Game mastering in serious games is often application-dependent. In game-based learning, for instance, the game master may have the role of a tutor or instructor at the same time; Chap. 8 discusses game mastering together with social aspects of serious games, especially in multi-player games.

The third part takes a look at the effects of serious games and their evaluation. Chapter 9 discusses the goal to entertain and shows how the game experience can be measured. It also introduces the term *player experience*. In addition, evaluation techniques that are vital for games in general (such as the evaluation of the game's usability) are addressed. Chapter 10 focuses on the assessment of how far the characterizing goals are met that are unique for serious games. In this chapter, evaluation techniques are presented, and indicators for the performance of a serious game are identified.

Finally, the topic of the fourth part is serious games in practice. First, Chap. 11 addresses economic aspects such as budgeting, cost benefit analyses, and serious game distribution. A collection of many examples of serious games is contained in Chap. 12 where each set of examples highlights a different characterizing goal.

1.7.2 Readership

Primarily, this book is a textbook that can serve as an accompanying text for a course, an introductory text for a seminar paper on a specific topic in serious gaming, a book of reference, or a basis for self-study. Serious games are always the result of interdisciplinary work. Appropriately, students of various disciplines (such as computer science, communication design, game design, pedagogics, psychology, or the humanities) are the main target group of this book. Chapter 2 provides brief introductions to these different disciplines.

Prospective users of serious game technology may find this book helpful as it provides them with a solid basis for judging the advantages, limitations and application areas of serious games. This target group will find part IV of the book with its application examples and the discussion of resources and other economic aspects particularly useful. Readers will be able to develop an understanding for the production process and to assess its complexity. Moreover, they will be provided with a methodology to evaluate if a serious game meets its goals.

Prospective developers of serious games are another target group of this book. Specifically, if developers are already familiar with games for entertainment, they can learn more about the specific issues regarding serious game design and development.

1.7.3 Teaching Suggestions

The modular design of this book allows it to cater to different learning goals and needs. Readers and instructors are able to choose what learning content they find appropriate. In the following, you can find five suggestions for courses (assuming one semester, two hours per week, 150 h workload) which can also serve as recommendations for self-studies of particular topics. Those suggestions should be adapted by instructors to individual student knowledge and interests.

Example 1: *Introduction to Serious Games*
Chapter 1, first four examples of Chapter 12, Chapter 3, Chapter 5, Chapter 7, Chapter 8, Chapter 10

Example 2: *Entertainment Technology*
Chapter 1, Chapter 4, Chapter 6, Chapter 5, Chapter 7, Chapter 2, Chapter 3, Chapter 9

Example 3: *Serious Game Design*
Chapter 1, Chapter 2, Chapter 3, Chapter 7, Chapter 8, Chapter 4, Chapter 9, Chapter 10, Chapter 12

Example 4: *Game-based Learning*
Chapter 1, Chapter 2, Chapter 3, Chapter 9, Chapter 10, Chapter 4, Chapter 5, Chapter 12

Example 5: *Applications of Serious Gaming (e.g., Serious Games for Health)* Chapter 1, Chapter 12 (selection of application examples), Chapter 7, Chapter 8, Chapter 9, Chapter 10, Chapter 2, Chapter 3, Chapter 4, Chapter 11

Moreover, the book can serve as additional literature in a course (e.g., about game development or e-Learning) that touches on the subject of serious games. Here, reading Chap. 1 is recommended, followed by application examples for illustration (Chap. 12) and based on a selection of the specific chapter of interest.

1.8 Summary and Questions

Serious games are digital games where developers desire more than a singular goal to entertain, and pursue one or more characterizing goals. A typical characterizing goal is that the player learns something (e.g., facts about a subject, or specific skills). However, serious games are broader than just educational games. For instance, exergames pursue characterizing goals to both promote a healthy lifestyle and increase players' physical fitness. An additional characterizing goal besides entertainment affects the development process of a serious game, where subject-matter experts are included as part of the development team.

As a characterizing goal has a severe impact on game design, there will be a new tradeoff with existing entertainment goals. Experience shows that this tradeoff is solvable; many games exist that are both fun to play and serve a more serious purpose. Although the history of serious games shows that the idea of games having a serious purpose is not new—with serious games existing right after the invention of digital games—their development and usage is still a challenge today.

Check your understanding of this chapter by answering the following questions:

- Why is it necessary for a serious game to have an identifiable outcome?
- *Foldit* is an online game by the University of Washington where players solve puzzles concerning the 3D structure of proteins. Observing the players, researchers try to find algorithms for how a 3D protein structure can be predicted. Is *foldit* a serious game? If so, what is its characterizing goal? Can *foldit* be considered the result of a gamification process? Can *foldit* be classified as a game with a purpose?
- What are the differences between developing an entertainment game and a serious game? How does the characterizing goal of a particular game affect the differences?
- What are the additional costs for the development of serious games compared to entertainment games?

- Why are adaptation and personalization especially important for serious games? Which steps are necessary to establish personalized, adaptive serious games that match the needs and characteristics of individual users and user groups?
- Assume you need to create a serious game that raises awareness about sexually transmitted diseases (STDs). Budget limitations dictate that you could afford to hire at most five persons for the development team. What roles would you assign to the team members? Which skill set would you look for in each team member? How would you start the project in order to come up with a game idea? What could a suitable project plan look like?
- Do some research on input and output devices that are used for games. Assemble a list of 20 devices. Make a list of 10 characterizing goals for 10 potential serious games you can think of. Are there any specific input and output devices that would be particularly suited to reach the characterizing goal in each of the ten games?

Recommended Literature[1]

Ma M, Oikonomou A, Jain L (2011) Serious Games and Edutainment Applications. Springer, London, UK—*provides a pragmatic approach to the research and application area of serious games and edutainment applications. Case studies and underlying research and development aspects are covered, as well as business aspects and guidelines on how to use a serious game, e.g., in a classroom setting*

[1]Original work in game research and serious games research is introduced and published by a number of well-established scientific conferences in the field of artificial intelligence (e.g., AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, short: AIIDE), human-computer-interaction (ACM CHI Conference on Human Factors in Computing Systems), multimedia (ACM International Conference on Multimedia) or computer graphics (International Conference and Exhibition on Computer Graphics and Interactive Techniques, ACM SIGGRAPH) as well as business-oriented conferences and events (e.g., the Game Developers Conference or gamescom). Games-related scientific conferences include: Foundations of Digital Games, Advances in Computer Entertainment, International Conference of Interactive Digital Storytelling, and the International Conference on Entertainment Computing. Specialized international conferences include: eLearning and Games (Edutainment), European Conference on Game-based Learning, European Conference on Technology-enhanced Learning, and Games for Health in the fields of education and health. The few conferences that are specifically dedicated to serious games are: International Conference on Serious Games Development and Applications, International Conference on Games and Virtual Worlds for Serious Applications, and International Conference on Serious Games (originated by GameDays). Similarly, a number of scientific journals have been set up in the area of games, serious games and entertainment computing: International Journal on Artificial Intelligence in Education, International Journal of Game-based Learning, International Journal of Serious Games, Games for Health Journal, International Journal on Technology-enhanced Learning, IEEE Journal of Educational Technology and Society, IEEE Transaction on Learning Technology, Journal of Learning Science, Journal of Technology and Teacher Education, Journal of Usability Studies, Journal of Virtual Worlds Research, Journal of Virtual Worlds and Education, and Simulation and Gaming.

Ritterfeld U, Cody M, Vorderer P (2009) Serious Games—Mechanisms and Effects. Routledge, New York and London—*tackles the nature of serious games from a social science perspective, in the context of various best practice examples in the field of serious games for learning, serious games for development, and serious games for social change*

Bredl K, Bösche W (2013) Serious Games and Virtual Worlds in Education, Professional Development, and Healthcare. Information Science Reference (an imprint of IGI Global), Hershey PA—*primarily addresses educators indicating the potential of digital games for its use in multi-user instructional (learning) environments. Technically, methods and concepts for the creation (authoring), control and evaluation (measurement of effects) are described in the context of digital educational games and games for health*

Rabin S (2009) Introduction to Game Development. Second Edition. Charles River Media, Boston—*a standard textbook on the topic of entertainment games*

Salen K, Zimmermann E (2003) Rules of Play: Game Design Fundamentals. MIT Press, Cambridge, MA—*provides a benchmark in the field of game design. This includes a model for analyzing and understanding games as well as fundamental concepts such as "play," "design," and "interactivity" towards the creation of games and (playful) interactive systems in general*

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