Master Thesis

Automatically Generated Learning Content for an Educational Game

Thomas Kutschker

born on 27.10.1988 in Rosenheim
student ID 1244615

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Supervisor: Dr. Benjamin Guthier

Department of Computer Science IV
Prof. Dr.-Ing. W. Effelsberg

School of Business Informatics and Mathematics
University of Mannheim

Abstract

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1 Introduction

Everyone loves to play with cards. You can learn new words by cards, staple them as a card house or just socialize with other people at cozy nights with friends. Most of the card games are produced for entertainment purposes including Skat, Uno or poker. As the same card deck can be reused in multiple games, it is easy to invent new ones by modifying the rules. For example the german card deck contains 32 playing cards and is used for 'Skat' and 'Schafkopf' whereby the second one is a traditional Bavarian card game. But cards can also be used to transmit knowledge and information about interesting topics. Children can learn new things they did not know and adults can test their knowledge in a competitive manner. Querying the game database of BoardGameGeek[1] returned about 1400 card games with an educational background. Maybe the best-known card game is 'Trivial Pursuit' which was invented in the year 1981. The goal is to get all one stone from each of the six categories (Geography, Entertainment, History, ..) by giving the right answer to the questions on the cards. Today many different versions exist with focus on different topics. Another well-known game category are quartets like card games. Game variants of quartets are for example 'Go Fish' or 'Top Trumps' thereby all have in common that a player can win the game if he get all cards from the opponent. Each of the cards in 'Top Trumps' contains a list of numerical data about the item of the card and based on predefined rules a card is won if the played value is higher or lower than the opposite one.

The prototype for this master thesis is a combination of the mentioned educational games. The main idea was to create a game similar to 'Top Trumps' that does also include non-numerical values. Therefore a player cannot only win a card with a higher/lower value compared to opposite player's value (as 'Top Trumps'), but also by knowing the correct value/answer (as 'Trivial Pursuit'). The basic construction of the game will be described in section 4.1. But the main problem of these games is the limitation to one topic per card deck as you buy one deck and then you play the whole time with same cards and topic. It is clear that players get bored after a few rounds as they know the strengths and weaknesses of the cards and no new items appear. For the 'Top Trumps' card game decks with new topics were sold that covers a more divers field of categories including vehicles, sports, entertainment or pets. Moreover, BoardGameGeek shows 199 different versions for the game 'Trivial Pursuit' that include but are not limited to 'Bayern', 'Olympic' or 'World of Warcraft' editions. For some of these games an online version was created, for example the german newspaper magazine 'Spiegel Online' published a 'Trivial Pursuit' version on their website that is based on the rules of the original game. The advantage is that new questions can easily be generated and included

[1] https://boardgamegeek.com

in the game so that the users are confronted with new questions each time they starting the game.

To create the questions for these games mainly two possibilities exists. First of all the questions can be generated manually by users themselves who play the game. An example is the mobile application 'Quizduell' where the players can submit a question with corresponding (wrong) answers. One challenge with manually created questions by users is the motivation to submit them, 'Quizduell' solves this problem by generating a ranking list showing how many questions a user has submitted. As part of gamification this will be discussed in section 2.3. Secondly the content for the questions can be generated automatically. In this case existing content from the web is used to create questions thereby wrong answers can be generated by similar resources of the same topic. This method was used for the educational game 'WhoKnows' in the article by Ketterl et al. (2011). The content is based on the linked dataset DBPedia whereby the semantic data is extracted from Wikipedia. It is clear that with this approach there is no limitation towards the number of questions as the content is generated automatically. One disadvantage is that much effort must be put into data preprocessing to ensure a high quality of data. Advantages and disadvantages of both approaches will be discussed in section 4.1.

Beside the automatic generation of content one important goal of this thesis is the effect of games on learning outcome. Generally these games can be classified as educational games (see section 2.2.3). Randel et al. (1992) collected several research results about the usefulness of games for educational purposes including subjects like maths, biology or physics. 32% of the simulations favors the usage of games over traditional teaching. Seven of eight math studies revealed an improvement of math skills by using games for learning. Therefore, one way to measure a positive learning effect of the prototype in this thesis is to examine the number of correct answers over time. Beside this research, also the effect of gamification elements on learning motivation is evaluated. This includes but is not limited to the influence of time and challenge (Ronimus et al., 2014), rewards (Filsecker and Hickey, 2014) and competition (Cagiltay et al., 2015) on the motivation of the users to play the game and to learn new things.

Additionally the performance of the game will be evaluated, relevant studies were conducted for example by Ketterl et al. (2011) who analyzed the data quality of DBPedia. One key factor for the performance of a game is the velocity of the system, for example how long it takes to create a new game. Moreover we want to find out how stable the DBPedia website availability is. The reason for this step was the low availability of DBPedia during the Hackathon. This was evident in the fact that the site for several minutes could not be reached. Since we would create the questions through a live access to DBPedia a 100% accessibility is a prerequisite for productive use. Our game is intended to show whether it is necessary to download a dump of DBPedia in order to ensure high availability.

The third measurement parameter that will be evaluated is the acceptance of the game by the users. It means how the player like the game or how motivated they are to keep playing. However, this is highly subjective from the point of view of the user as the results in this area are collected with the help of a survey. There exits some

studies in the literature about the perception of the users, for example Siorpaes and Hepp (2008) conducted a survey where he asked questions about the perceived difficulty, rule understanding and the enjoyment of the game. There exists many game elements that influence the motivation of a user: rewards, social interaction and ranking lists. All of these elements do not directly influence the learning skill of a player, however it will be interesting to find coherences between the subjective perception of motivation and the actual position in the ranking list. This leads to the research question for this thesis.

> What impact have game elements on the motivation and learning skill of the players?

To achieve this goal an educational game was created to evaluate performance of system, acceptance of players and learning effect. Three reasons exists that explains the motivation for this master thesis. First of all I participated in a Hackathon programming challenge[2] in Mannheim on April 2015 where we created a similar game prototype[3] in 24 hours in a team of three. The goal was to create an application that deals with the topic 'education'. We created a quartet like game that was purely based on WebRTC technology with the purpose to retrieve the data for the cards from DBPedia. We got positive feedback from many different people, although we could not established a stable connection to DBPedia at that time. Thus I wanted to finish and expand the prototype created as part of the master thesis. Thirdly I want to find out if different game elements - as part of gamification - have an influence on learning outcome of the players. Especially I'm interested in the effect of guidance before starting the game (warm-up phase) and how many users will use this tool and how long to get a competitive advantage.

The master thesis is constructed as follows. First an overview is given in chapter 2 over the fundamentals of this thesis to get a basic understanding of the scope which are necessary for next chapters. That includes explaining the term 'Game Thinking' as an umbrella term for (serious) games and gamification. Next serious games are defined and different approaches are established to classify several serious games. Especially edutainment is described in its own section as the prototype of this thesis can be classified as an educational game. In the next subsection the area gamification and the two different types of gamification - structural and content gamification - and the corresponding game elements that are part of gamification are demonstrated as this scope plays an important role in this thesis. The last section of the fundamentals deals with the semantic web and the reasons why there is the need for this approach. As the content of the game is generated automatically from the linked dataset DBPedia, this semantic web project is specifically explained in the last part. All fundamentals of this thesis contains references to relevant literature to get a basic understanding of the scopes discussed in this thesis. In chapter 3 we will create a model that includes all key factors which influence the learning of the users regarding motivation and improvement of skills. It includes both game elements from gamification area and deals with the automatic generation of content based on DBPedia. The model is based on relevant literature and tries to build

[2] http://www.hackerstolz.de/de/eduhacks-2015-de/

[3] https://www.hackerleague.org/hackathons/edu%7Bhacks%7D-mannheim/hacks/eduhacks-quartett

a framework for further research. It is the basis for chapters 5 and 6. Before describing the results in chapter 5, the prototype development is shown in chapter 4. That includes the main idea of the game, architecture, data preprocessing, user interface, game logic, deployment and testing. Chapter 5 contains the analysis of the results from game and the survey. It includes the performance of the system regarding the consistency, speed and usability of content. As the questions for the game are generated automatically, it is important to analyse the stability of the system. Additionally a survey was sent too all user where they should describe their subjective perception of the game regarding fun and motivation. This survey also includes some questions about the perceived usefulness of the game for learning purposes. Beside the subjective perception in terms of learning, it will also be evaluated in this chapter how the different game elements influence the learning skill of the players. Chapter 6 deals with a critical evaluation of the results. For this purpose several hypothesis will be established thereby they are either denied or accepted based on results and related literature. In the last chapter we will describe the main limitations of this thesis and give an outlook of possible improvements that can be made to increase the skill and motivation of the users. It includes for example the effect of total number of players on motivation and the hypothesis if it would decreases or stay the same.

To understand the scope of this thesis, the following chapter starts with the description of the different areas by referencing related articles found in the literature.

2 Fundamentals and Related Work

Where are many reasons for the gaming industry to develop other games beside just for entertainment: health care and eduction are just two of them. Such games can be classified as serious games, therefore it is important to understand the concept of this type of game and how it differs from normal games. The different types of serious games will be shown and particularly edutainment games as this covers the scope of this thesis. Afterwards the term 'Gamification' will be introduced as the prototype contains several elements of this type. Furthermore 'Game Thinking' will be discussed as a possible umbrella term for games to be able to distinguish between gamification, serious and other games. In the last section I will describe the concept of semantic web. Semantic data is used to generate the data for the prototype. DBpedia, a project to extract content from the web, will be used as a basis for the content.

2.1 Game Thinking

Before thinking about Gamification and (Serious) Games it is important to understand how they are connected in terms of games. For this purpose we introduce an umbrella term that connects all areas so that it is possible to group different game elements (e.g. design, gamification or games) and to be able to distinguish between game types: Game Thinking. This term was used in the book by Werbach and Hunter (2012) for the first time, and describes all actions in relation to games to support business. It is defined as "the mind-set required to deploy fun in a considered and directed way". Game elements are therefore used to achieve a certain behavior by giving the user an engaging experience. These behaviors can be anything like encouraging problem solving, promoting teamwork or giving players some form of control over the game so that the player experience fun while playing a game. Thus Game Thinking is all about thinking like a game designer: what motivates a player to deal with the game. The problem with the description of Game Thinking in the book is the limitation to Gamification. Of course many resources from this area can be used to engage the users and motivate them to play a game, but there exits many elements beside Gamification that are important for the motivation of players. So for example if a company uses a puzzle for advertising purposes, it has nothing to do with Gamification, but must be considered as a part of Game Thinking (in form of Game Inspired Design). Marczewski (2013) wrote in his blog about Game Thinking and what comes under this area. He uses 'Game Thinking' as an umbrella term comprising gamification, serious games, game-inspired design, and play that can be used to solve some sort of problem (see Figure 2.1). Now, as not only Gamification is considered, it is possible to classify the different game elements into the different scopes.

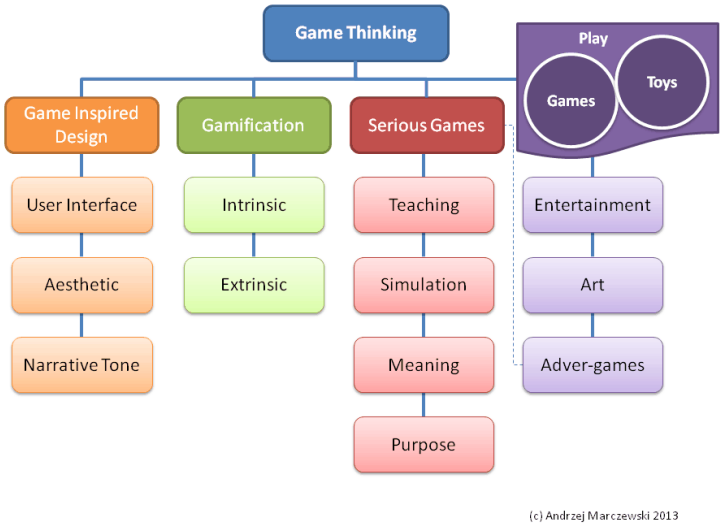

Figure 2.1: Game Thinking types.[1]

Game-like approaches are all game elements that do not add game content, but that support and motivate the user to deal with the content itself: game inspired design and gamification. Game inspired design is the attempt to add game elements to the content to increase the usability and add a value to the user experience in the interaction. Apart from that it does not increase the information content. A good example for a game inspired user interface are the Doodles on the Google search web site. For the 2012 Summer Olympics in London several Doodles were created like a hurdling competition[2] where the user could control the runner to finish in a specific time. This alteration of the logo does neither modify the search results , nor is mandatory to use. The second game-like approach are gamification elements that are best known as points, leaderboard or the social interaction between players like a chat window. A definition of gamification and what the difference between intrinsic and extrinsic are described later in section 2.3. The second part of the definition deals with the usage of games to increase user experience, thereby it is distinguished between serious games (see section 2.2) and Games/Toys. The majority of games can be put in this category, e.g. Grand Theft Auto (GTA) or World of Warcraft. GTA is a good example for a game that is developed just for entertainment. In some scenes it encourages violence against women and supports the usage of weapons against other persons. One consequence - that such a game produce physiological desensitization to real-life violence - is described in the article of Carnagey et al. (2007). So while the majority of serious games contain a positive purpose, games produced for entertainment does not or most often have a negative purpose.

[1] http://www.gamified.uk/wp-content/uploads/2013/02/Game-Thinking-4.png
[2] https://www.google.com/doodles/hurdles-2012

For the educational game of this thesis two parts of Game Thinking are important: Serious Games and Gamification. Both will be explained in the next sections.

2.2 Serious Games

The primary goal of an educational game is not entertainment. In the best case the user should have a learning effect during the game. For this purpose it is mandatory that he can access learning material before starting the game to gain an advantage over the opponent player. In the following section the topic serious game is discussed and how the prototype of this thesis can be classified in this context. Furthermore I want to explain the possibility of legal cheating to gain an advantage for the game and the positive side effect that the player hopefully memorize the content after the game.

2.2.1 Definition

Before thinking about a proper definition of serious games it is important to understand the meaning of a game. So lets start with a distinction whether games can be seen as toys or if they differ from each other. A toy is something to play with and has the primary goal to entertain the person who plays with it. Considering these attributes it is not possible to distinguish between a game and a toy as they share the same properties. Additionally a toy is used to be something real that you can hold in your hands. Brooks (1986) distinguishes between a toy and an artificial intelligence (AI) system in a way that as soon as the AI system is not fully responsible for the actions made and there exists no human who has to interpret the results of the system, then the toy is part of an (intelligent) system. While this definition holds for the distinction between toys and virtual games, it is still not possible to distinguish between toys and real-world games. For this purpose I want to introduce a definition of Cayatte (2014) who describes something as a game as soon as some rules are added to it. This means if you have just a ball than it is a toy, but if you add a goal and some rules that a team wins if they score one goal more than the opposite team the situation is transferred into a game. In the developed game for this thesis one player can win the card if he give the correct answer, therefore there exists some rules and after the definition of Cayatte (2014) the prototype can be classfified as a game. It would be just a toy if only the cards and the players would exist and if there would be no competition between the players.

By now we know a game is a toy that has some rules and goals attached to it but what is still missing is the classification of serious games in this context. Video games in contrast to serious games are described as a simulation of reality (Grodal, 2000) and with the primary purpose to entertain people (Hsu and Lu, 2004). These attributes are combined in the article of Zyda (2005) who defines video games as 'a mental contest, played with a computer according to certain rules for amusement, recreation, or winning a stake'. So even if it does not hold for all video games, the primary purpose of a game is entertainment.

This classification can also be found in the model by Marczewski (2013), that was created to distinguish between the types of Game Thinking by their primary design goal

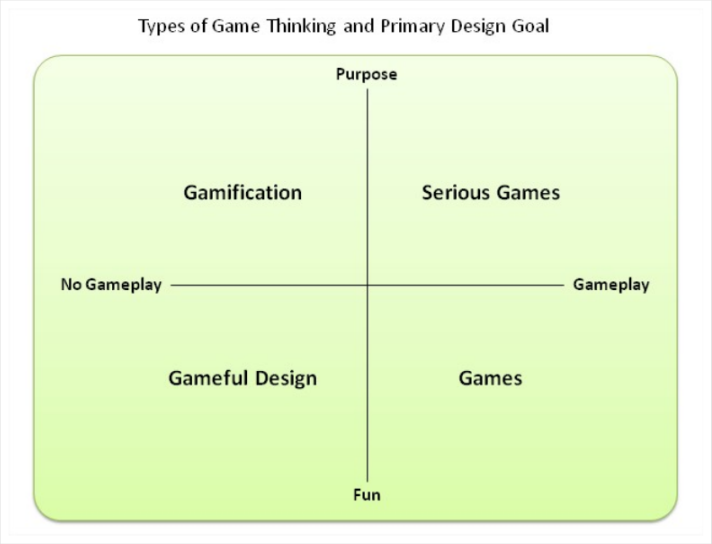

Figure 2.2: Game Thinking goals.[3]

(see figure 2.2). It is also a good reference to find a definition for Serious Games. The term was well-defined in many papers with few modifications, but in fact they don't differ so much from each other. 'Serious Games' were first described in the book of Abt (1987) by the idea of teaching with games. They can help the students to acquire new knowledge not just by observing the results but also by playing with them. This book is a good basis for a general definition of serious games but in time the book was written video games were not invented yet. Zyda (2005) defines serious games by expanding the definition by adding video games into the context. Following his interpretation a game can be classified as a serious game if some pedagogy elements are added. Therefore the game principles built for the purpose of entertainment are needed to facilitate other objectives beside pure amusement. We want to summarize all these interpretations of Serious Game area into one definition by Djaouti et al. (2011) that will be used in this thesis:

> "use people's interest in video games to capture their attention for a variety of purposes that go beyond pure entertainment"

Regarding the educational game a good example are the online poker games where people plays card for fun and to earn money. We use this interest in card games to create an educational game with the primary purpose to equip the players with knowledge.

2.2.2 Types of serious games

While the term 'Serious Game' is well-defined there exists no commonly accepted list how to classify serious games into different areas. Going back to the model (see figure 2.1) of Marczewski (2013) serious games are classified by the following four types: teaching, simulation, meaning and purpose. While it is possible to mark a game as serious

with this model, we need an approach to split up these categories into more detailed sub-categories. There exists two approaches to classify games into more specific categories. This is done by the two criteria market and purpose. Market-based approaches can be found for example in the article by Zyda (2005) who divided Serious Games into seven domains: Health, Public policy, Strategic Communication, Human performance engineering, Training & Simulation, Education and Game Evaluation. Michael and Chen (2005) classified Serious Games in their book according to eight different categories: Military Games, Government Games, Educational Games, Corporate Games, Healthcare Games, Political Games, Religious Games and Art Games. The market-based classification is independent of the purpose of the game, therefore it does not matter if a game is developed for learning or advertisement. Thus it may be hard to classify a game as serious game as it can be produced for normal and serious game market. The other approach is the purpose-based classification of serious games. It can be found in the book by Bergeron (2006) whereby serious games are divided into five main categories "games with an agenda, news games, political games, realistic games and core competency games" and two secondary categories "adver-games and modifications". The main difference to the market-based approach is the missing educational category. Bergeron stated out that each of the five main categories are variations of educational games and therefore there is no need to explicitly enumerate this category. But also this approach has the problem that a clear classification in serious games is not possible. Thus, there is the need for a combined approach. Sawyer and Smith (2008) combine these two criteria - market and purpose - to classify serious games. The games are split into the following categories:

- **Market-Based**
  Government & NGO, Defence, Healthcare, Marketing & Communication, Education, Corporate and Industry

- **Purpose-Based**
  Games for Health, Advergames, Games for Training, Games for Education, Games for Science and Research, Production and Games as Work

They then combine these two criteria into one table to find sub-categories for each (see figure 2.3).

This taxonomy is in more detail than the previous approaches, but some of the subcategories overlap and therefore it seems that some additional work must be done to find distinct categories. Based on this model, Djaouti et al. (2011) created the "G/P/S model" to eliminate the duplicate sub-categories and to be able to classify games in serious games area. The "G/P/S model" consists of three aspects gameplay, purpose and scope. Gameplay refers to the type of gameplay used and contains information how the game is played. There exists two types of gameplay, the first one is "Play-Based" referring to games without goals and "Game-Based" that contains some form of goals. Three purposes exists in the model: message-broadcasting, training and data exchange.

[4] https://thedigitalentertainmentalliance.files.wordpress.com/2011/08/serious-games-taxonomy.pdf

	Games for Health	Advergames	Games for Training	Games for Education	Games for Science and Research	Production	Games as Work
Government & NGO	Public Health Education & Mass Casualty Response	Political Games	Employee Training	Inform Public	Data Collection / Planning	Strategic & Policy Planning	Public Diplomacy, Opinion Research
Defense	Rehabilitation & Wellness	Recruitment & Propaganda	Soldier/Support Training	School House Education	Wargames / planning	War planning & weapons research	Command & Control
Healthcare	Cybertherapy / Exergaming	Public Health Policy & Social Awareness Campaigns	Training Games for Health Professionals	Games for Patient Education and Disease Management	Visualization & Epidemiology	Biotech manufacturing & design	Public Health Response Planning & Logistics
Marketing & Communications	Advertising Treatment	Advertising, marketing with games, product placement	Product Use	Product Information	Opinion Research	Machinima	Opinion Research
Education	Inform about diseases/risks	Social Issue Games	Train teachers / Train workforce skills	Learning	Computer Science & Recruitment	P2P Learning Constructivism Documentary?	Teaching Distance Learning
Corporate	Employee Health Information & Wellness	Customer Education & Awareness	Employee Training	Continuing Education & Certification	Advertising / visualization	Strategic Planning	Command & Control
Industry	Occupational Safety	Sales & Recruitment	Employee Training	Workforce Education	Process Optimization Simulation	Nano/Bio-tech Design	Command & Control

Figure 2.3: Taxonomy of Serious Games.[4]

"Message-broadcasting" means that the game is designed to broadcast a message, "training" that the game is designed to improve cognitive performance or motor skills and "data exchange" that the game is designed as support for exchanging data thereby a game can be designed for none, one or all of these purposes. The scope aspect is a merged list of the previous found literature by (Zyda, 2005), (Michael and Chen, 2005) and (Bergeron, 2006) and contains the following categories: State & Government, Military & Defense, Healthcare, Education, Corporate, Religious, Culture & Art, Ecology, Politics, Humanitarian, Advertising and Scientific Research. Thus this list refers to the targeted application and the players who will use the game.

With the help of this model it is now possible to classify the educational game of this thesis as a serious game by the following aspects.

- **Gameplay**
  There exists some clear rules that a player win the round if he give the right answer. Therefore the game is a "Game-Based" approach as the the player either get a positive (win the card) or negative (loose the card) feedback.

- **Purpose**
  The game is definitely designed to broadcast a message, more precise transmit educational knowledge. It is neither designed to improve a specific skill of the players nor to collect information from the players.

- **Scope**
  The target audience are people who want to learn something by playing games. Therefore the game refers to the education category in the list.

In this case it is clear that the game can be classified as a serious game as most of the educational games on the market are designed for learning purposes. In the next section this market will be described in detail by giving some references to other educational games on the market.

2.2.3 Edutainment

Educational games are the only type of game that is universally accepted as a type of serious games. It can not only be found in the "G/P/S model" (Djaouti et al., 2011) but also in the other articles [(Zyda, 2005), (Michael and Chen, 2005) and (Bergeron, 2006)] in the last section. In the Game Thinking model by Marczewski (2013) educational games are classified as teaching games with the purpose to teach the players some content using real gameplay. As opposed to this, games of this type are labeled as "Edugames" in the paper by Djaouti et al. (2011) with the purpose to impart educational knowledge via gameplay thereby the term is a composition of the words "education" and "games". Most often these games are just referred as educational or learning games as there exists no common name for this type of game. In most of the models only the transmitting of educational knowledge is considered and the entertainment aspect is dismissed. This is in line with the definition of a serious game that the purpose of a game goes beyond entertainment, but in fact it seems not possible to cut out entertainment completely from this scope. In the "G/P/S model" entertainment is not party of the scope list, but is mentioned explicitly to be included in the list. Thereby we have to expand the list created by Djaouti et al. (2011) by adding entertainment to it.

As an example for a game that was designed for both entertainment and education is the game "America's Army"[5], a first person shooter developed by the American army. Nieborg (2004) established four dimensions in the game: recruiting tool, propagame, edugame and a test and bed tool for the US army. The game was designed as a recruiting tool for the army and to create good publicity in the public. The third dimension correlates to edugames as beside a public version also a governmental version exists. This version servers as a training tool for the soldiers. Furthermore the purpose of the game is to transmit knowledge and information about the army. The test & bed tool dimension refers to several case studies conducted by the army to evaluate cognitive abilities of the players. The fifth dimension not mentioned in the article is entertainment as most of the users play this game just for fun.

Such games fall into the scope of edutainment thereby this term is a portmanteau of the words "education" and "entertainment". In the article by Okan (2003) edutainment is described as a hybrid genre that relies on three aspects: visual material, game-like formats and more informal styles of address. Edutainment suggests entertaining learning material which should raise the learner's expectations that learning can be enjoyable and

[5] https://www.americasarmy.com/

fun. Charsky (2010) describes the purpose of edutainment as the teaching of lower order thinking skills. It means that game designers makes no attempt to "teach gamers how to apply their knowledge, analyze their understanding, synthesize their perceptions, or evaluate their learning".

There exits many games of this type on the market, Djaouti et al. (2011) created a web page[6] to identity serious games by their gameplay, purpose and/or scope. Conducting a market-based search on this web page including the scopes "entertainment" and "education" leads on to 1157 serious games. All of these games can be classified as edutainment games.

To sum up, one could say that entertainment must be considered when classifying serious games even if it is no part of most definitions. Now it is possible to classify the educational game for this thesis as an edutainment game as it includes both entertainment and education aspects. The main reason for this classification is the paper by Charsky (2010). In a optimal case, the gamers should gain some knowledge through playing with the cards, but they neither can apply nor evaluate their knowledge after the game.

2.3 Gamification

This section deals with techniques and elements to engage and motivate users to play a game. These techniques are called Gamification and can be divided into intrinsic and extrinsic elements.

2.3.1 Definition

The term 'Gamification' was first used on the company website of Conundra Ltd.[7], a consulting company founded by Nick Pelling in year 2002 with the goal to implement game mechanics so that every device is transformed into a game. However, the focus at this time was only on the hardware component. Few years later the company Bunchball[8] (launched 2005) adapted the term gamification and used it in software context. They described gamification on their website in the following way:

> "Gamification is the process of taking something that already exists – a website, an enterprise application, an online community – and integrating game mechanics into it to motivate participation, engagement, and loyalty. Gamification takes the data-driven techniques that game designers use to engage players, and applies them to non-game experiences to motivate actions that add value to your business."

This description of gamification is mainly based on the article of Deterding et al. (2011) who defined gamification as "the use of game design elements in non-game contexts". The game design elements are restricted to the following three aspects: (a) found

[6] http://serious.gameclassification.com/EN/index.html
[7] http://www.nanodome.com/conundra.co.uk/
[8] http://www.bunchball.com/

in most games, (b) readily associated to games and (c) play a significant role in gameplay. Although a complete list of elements cannot be found in literature, a good starting point is the book by Read et al. (2009) who created a list named "Ten Ingredients of Great Games": Self-representation with avatars; three-dimensional environments; narrative context; feedback; reputations, ranks, and levels; marketplaces and economies; competition under rules that are explicit and enforced; teams; parallel communication systems that can be easily configured; time pressure. Compared to the restrictions by Deterding et al. (2011) not all elements of this list are relevant in terms of games as for example avatars are used in most of Massively Multiplayer Online Role-Playing Game (MMORPG) games but not at all in strategic games. Bunchball publishes an own list of game design elements on their web page that includes the following items: fast feedback, transparency, goals, badges, leveling up, onboarding (easy missions for new users), competition, collaboration, community and points. Although both lists overlap in many aspects, there exists some differences between them. I will go into more detail about game design elements in section 2.3.2. Non-game context means the usage of game elements for purposes other than their expected use (Deterding et al., 2011) to motivate desired behaviors (Deterding, 2012). Examples of desired behaviors can be found in the cited statement above by Bunchball: motivate participation, engagement and loyalty. However, Deterding et al. (2011) recommends that gamification should not be limited to any specific usage context, purpose or scenario. Instead it is suggested to create subcategories parallel to Sawyer's taxonomy of serious games (figure 2.3) with usage contexts or purposes as potential names for these categories. These subcategories are not labeled in the article but there exists many examples in the real world. For example display the produced entities and goal for the day in front of the conveyor line motivates the workers to reach this goal. Another example are ranking lists or employee of the month to gain a competitive atmosphere inside the company. Therefore subcategories could be competition or motivation.

Summarizing gamification is a great opportunity to motivate the gamers keep playing. The main reason why gamification works lies in the nature of people to be better than others and who want to get as much rewards as possible. In the next section game design elements are described in detail with reference to games that use gamification to support their business.

2.3.2 Structural and Content Gamification

In the previous section some examples for game design elements were listed but they are neither sorted nor classified along some categories. Therefore, there is the need for some form of classification. According to Kapp (2012) there exists two types of gamification: structural and content gamification. Structural Gamification means the usage of game elements to motivate a player through the content without modifying the content itself. In the Game Thinking model by Marczewski (2013) structural gamification is defined as extrinsic gamification (see figure 2.1). The purpose of this type of gamification is to increase the motivation of players to go through content and to engage them to learn the content by getting rewards for playing. Examples for structural gamification can

be found in the list "Ten Ingredients of Great Games" of the previous section, namely reputations, ranks, and levels. A game that uses some of these elements is for example the multiplayer tank game "World of Tanks"[9]. The players get badges if they fulfill some task (e.g. destroy 6 or more tanks) or they can research and play with better tanks on more difficult levels against better players. However, the gamer always can look up his rank in a high score that is calculated by his performance in the matches.

Hamari et al. (2014) merged several articles that deals with the effects of structural gamification on learning outcome. The following game design elements were tested for structural gamification: points, leader boards, achievements/badges, levels, clear goals, feedback, rewards and progress. 9 out of the 24 empirical studies had an education/learning context thereby all of the studies in this category considered the learning outcomes of gamification as mostly positive (increased motivation to learn new things or enjoy learning). In one study the results of increased competition were evaluated to have an overall negative effect on learning outcome. Two other studies stated a negative coherence between learning outcome and task evaluation difficulties or design features. Although there exists an overall positive coherence between structural gamification and motivation, this effect only lasts for a short time (Farzan et al., 2008). In this study users got points for commenting a photo thereby the more they contribute the higher they were listed in a ranking list. Furthermore users could achieve different titles (newbee, busybee, workerbee, ...) which depends on the number of written comments. The motivation to contribute to the community decreases after time, one reason was that the points did not decay over time. Therefore there exists no motivation for a user to contribute more content if he reached a specific level. However, the points were an effective medium to motivate the users to comment more photos as they did not want to be seen as only a reader and furthermore most of the users wanted to reach the next level by actively contributing to the community.

The second type of gamification defined by Kapp (2012) is content gamification. In the model by Marczewski (2013) this type of gamification is referred as intrinsic gamification. It is defined as the usage of game elements to modify content to make it more game-like. There exists not so many game design elements of this type, however, the 'narrative context' in the list "Ten Ingredients of Great Games" is a good example for content gamification. In the case a game contains a narrative context, it means the telling of a story or account of events or experiences (Halan et al., 2010). In this study the answer participants were asked to reply to an email that contains a narrative about a medical scenario. It was evaluated if experimental group that got mails with narrative replied more often than the control group without this attachment. In summary, it can be stated that the response rate of the experimental group was much higher than of the control group, therefore the narrative was a great opportunity to motivate the people to reply to the mail. Another form of content gamification is starting a course with a challenge instead of a list of objectives (Kapp, 2012). A practical example would be asking the audience of a course to stand up at the beginning to answer questions (quiz like game). If a person deny a question he must sit down, the last standing

[9] http://worldoftanks.eu/

Structural	Content
Badges	Challenge
Leveling Up	Collaboration
Community	Competition
Points	

Table 2.1: Structural and Content gamification elements used in educational game

person is the winner of the quiz. That type of gamification increases the motivation to participate in the course and enhance the interest of people in the content. But it must be considered that most of the users only deal with more difficult challenges if a solution seems achievable (Friedemann et al.).

Our educational game contains several game elements to motivate the users keep playing the game (see table 2.1). The points the players get for playing the game (based on their performance) are used to calculate their rank and to build a highscore list of all users. Furthermore there exists different levels to represent the experience of a player (reference to Farzan et al. (2008)) whereby the users can level up by improving their performance. It is used to separate the players by their experience to protect new players. Badges are included in the profile of a user to encourage him playing more games and improving his performance. In the best case badges should have a positive influence on learning outcome of the player (Hamari et al., 2014). A chat in the lobby and in-game supports the social interaction between the players. Content gamification is used in form of challenge, collaboration and competition. Before starting the actual card game, the users can inform themselves about the playing cards that are included in the game. Therefore they can achieve an information advantage over the opposite player. Starting the game with a challenge (Kapp, 2012) should motivate the users to deal with the learning content. Furthermore there exists two game types, one that supports collaboration and the other one to enhance the competition between the players.

2.4 Semantic Web

In times of immense data it is important to structure information made available over the web. In the following section I will first explain the term big data and how the semantic web approach can help to structure and acquire this data in a standardize form. Furthermore DBPedia, a semantic web project that will be used as a basis for the prototype will be described in the last section.

2.4.1 Big Data

In a study of IDC Digital Universe (Turner et al., 2014) researchers figured out that the amount of data available in the web doubles every two years, that means from 2013 to 2020 the data will grows from 4.4 trillion to 44 trillion gigabytes. But at the same time only 22% of this data is useful in a form that it is tagged and analyzed.

This immense data is called Big Data and was first mentioned in an article of Gartner (Laney, 2001) where the following three dimensions were enumerated as challenges and limitation factors for large amount of data

- **Volume**
  One problem is the massive increase in data to be managed. It can be handled by purchasing more data storage facilities but at the same time the quality of the data decreases by redundancy of data and non-value data (only 22% useful as mentioned before). So the challenge is to determine these spots and either eliminate or transform them into useful data. But of course this require cost intensive operations to detect fault, useless or redundant data.

- **Velocity**
  Velocity means the time the data is available for active production, that means that the data is analyzed and tagged and therefore has a value for the user. With reference to Gartner (Laney, 2001), the point-of-interaction speed - that is for example the responsiveness of a website - can be an enormous competitive advantage. The difficulty is that with increasing amount of data also the time for analyzing increase and therefore it takes more time to get a value out of the data.

- **Variety**
  Variety of data is maybe the biggest problem for handling large amount of data. The term means that the data is neither structured nor is compatible among different datasets, that leads to plenty different data incompatible data formats. One solution is building bridges between different data types, for example structuring the data as XML or JSON format to make it accessible to other platforms.

The article was the first attempt to define the challenges of Big Data, although the term was not mentioned in the text, it is the key definition for this scope. There are many other articles about Big Data that expands the definition of Gartner. Jacobs (2009) refers to the increasing volume of data over time, but adds that it depends on the period of time. So for example while in the year 1980 a dataset with 100GB of size could not be handled by available methods at that time, today the limit is the amount of data that cannot be stored in relational databases or cannot be processed by hundreds of parallel servers. Ward and Barker (2013) collected different definitions and established similarities between them. As in Gartner's article the volume is a critical factor for Big Data. Furthermore all have in common that "the structure, behaviour and permutations of the datasets"(Ward and Barker, 2013) are characteristics of Big Data. What differs from the article of Gartner are the technologies as a limitation actor mentioned in the definitions. It depends on the tools and techniques used if large amount of data can be analyzed. For example while data can be handled by both Microsoft Excel and relational database systems, the second approach is much better for processing the data.
Regarding the prototype of this thesis two aspects of Gartners definition are important: Volume and Variety. Although only a subset of the 4.4 trillion gigabytes (Turner et al., 2014) are important for the prototype, there is the need for a technology to handle this

large amount of data. The second problem is the variety of data formats in the web as most of the valuable data is only available in unstructured format. One solution is the semantic web approach that will be described in the following section. It is the attempt to structure the data to make it possible to transfer Big Data between different platforms that may have different data formats.

2.4.2 Definition

As mentioned in the previous section one challenge of big data is the enormous range of different data formats. There exists no standard format how the data can be stored, some of the data in the web is completely unstructured and the rest is structured but contains different formats. The problem of unstructured data is that even if it can be read by humans, the same data may not be readable by machines. For this purpose the organization 'World Wide Web Consortium' (W3C) were founded to achieve a standardization of technologies in the world wide web. An example for a standardized interface is the Extensible Markup Language (XML), an attempt to write or transform unstructured into structured data to make it possible to exchange a wide variety of data on the web (W3C, 2015). But although XML is great for serialization of data - this means the translation of unstructured data to structured format - it associates no semantics with the meaning of the content. For this purpose the semantic web was created to make it possible to attach a meaning to the structured content. The term 'semantic web' was first described by Berners-Lee et al. (2001) to enable automatic reading of content by machines. Based on this article the term 'semantic web' was defined by W3C:

> "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries."

The semantic web is an extension of the web and is based on XML and RDF. As described before, XML provides only the elemental syntax for content structure within documents, but contains no information about the meaning respective meaning of the content. Although it is not a mandatory component of semantic web, it provides self defined tags as a basis for RDF. Resource Description Framework (RDF) is defined by W3C as "a framework for representing information in the Web". The RDF language - represented by triples - makes it possible to express the meaning of a sentence. Each triple consists of a subject, predicate and object. The subject represents the name of the node where the triple starts, the predicate defines the type of the edge between subject and object and the object as the third element of the triple describes the name of the target node where triple ends or a numeric or text value. The elements are represented by URIs (Uniform Resource Identifiers) to identify the subject, predicate and object in the web. By following the URI it is possible to get further information about the element.

For example if we want to define the airline 'Lufthansa' to be a 'Star Alliance' member it can be visualized as a graph (see figure 2.4).

The graph represents the following triple in DBPedia:

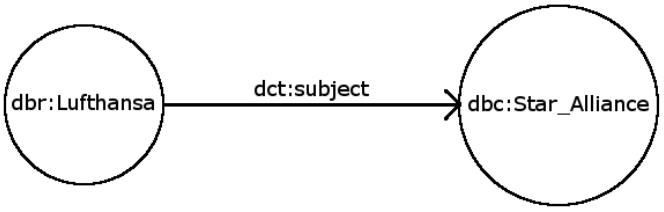

Figure 2.4: Visualization of RDF triple

- **Subject**
  Linked to the URI <http://dbpedia.org/resource/Lufthansa>. It represents the start node of the edge, following the link will returns all triples of this resource.

- **Predicate**
  Linked to the URI <http://purl.org/dc/terms/subject>. It represents the type of linkage between subject and object.

- **Object**
  Linked to the URI <http://dbpedia.org/resource/Category:Star_Alliance>. It represents the requested value of the triple, in this case 'Star Alliance'. As it contains an URI to another resource, it is possible to follow this object and receive all Airlines that are members of 'Star Alliance'.

In the next section some challenges are described that the semantic web is faced with.

2.4.3 Challenges

In section 2.4.1 the three challenges of Big Data - Volume, Velocity and Variety - were described as reasons for the need of semantic web approach. Richard and Contreras (2002) established a list of six problems that must be solved to achieve a high quality of data. DBPedia (see section 2.4.4) will be used to provide some solutions for these problems.

- **The availability of content**
  This problem is equal to first challenge of Big Data: Volume. It means that while the amount of data available in web increases, only 22% of this data is useful (Turner et al., 2014). This is caused by the limitations of HTML as neither syntax nor semantic meanings are attached to data. The solution provided by Richard and Contreras (2002) is the creation of annotation services that generate web content according to semantic web standards. Actually there exists no solution today to solve this problem to make the whole web readable by machines so that they understand the semantic of content.

- **Ontology availability, development and evolution**
  An Ontology is defined as a "specification of a conceptualization" (Gruber, 1993). It

can be best described as an umbrella term for all properties and relationships that are assigned to it. Ontologies are used in most of the linked datasets (DBPedia, Yago, ..) therefore this problem seems to be solved nowadays.

- **Scalability**
  Refers to the organization of semantic web content. The solution provided by (Turner et al., 2014) is the creation of semantic indexes to aggregate semantic web content based on associated topics. This is particularly implemented in the linked datasets by ontologies.

- **Multilinguality**
  Multilinguality is a big problem for the velocity the data is available. Wikipedia has around 300 editions in different languages therefore it is impossible to avoid wrong or old data. Therefore, if one page of wikipedia should be available in all languages, 300 different pages must be updated continuously. At the moment no solution exists to solve this problem. DBPedia is curently available in 128 languages[10].

- **Visualization**
  Refers to the easy recognition of relevant content for different purposes of users. To visualize RDF triples several tools on the market exists, for example Gephi[11]. With the help of these tools semantic data can be visualized (as figure 2.4) to illustrate the relationships between the different subjects, predicates and objects and to make it more understandable for humans.

- **Stability of Semantic Web languages**
  The technologies (RDF, XML, OWL, ..) are well-defined nowadays by W3C.

Even though some problems have been solved there are still a large number of data which can not be processed. Ontologies are used in most of the datasets to group resources by topics, but sometimes the reference is missing. In the following section DBPedia as an example for an linked data set will be explained in detail as it is used as data source for game.

2.4.4 Linked Data Sets

Cyganiak and Jentzsch (2011) created a 'LOD cloud diagram' that shows datasets that have been published in linked data format. The diagram was updated the last time on 2014-08-30 and contains 570 datasets that deal with semantic web data. The three most important datasets are DBPedia, Geo Names and FOAF profiles thereby their importance is calculated by the metadata attached to the datasets. DBPedia is a project to extract structured information from Wikipedia and to make it accessible on the web. The English version of DBPedia[12] (based on Feb/Mar 2015 Wikipedia data) contains 5.9

[10] http://blog.dbpedia.org/ (Accessed on: 03.01.2016)
[11] https://gephi.org/
[12] http://blog.dbpedia.org/

million resources including 2.06 million persons, 682 thousand places and 188 thousand organizations. In year 2009 Bizer et al. (2009) published an article about DBPedia with some numbers: 2.6 million resources, 198 thousand persons, 328 thousand places and 20 thousand organizations. This massive grow in just 6 years leads to 6.9 billion RDF triples of 2015 DBPedia version. 50 million RDF links exists to other linked data sets like Yago or WikiData. For every DBPedia resource at least one label exists - that is extracted from corresponding Wikipedia article - to name the entity. All resources contain at least one category thereby the two most common sources are DBPedia Ontologies and classes from Yago linked dataset. The DBPedia ontologies are created manually based on the most commonly used info boxes in Wikipedia. Yago classes are created by mapping Wikipedia leaf categories to WordNet synsets (Bizer et al., 2009). There exists two possibilities to extract data from DBPedia: Dump-based extraction and live extraction. To extract data from a Wikipedia dump, it is possible to download a dataset from DBPedia (newest release from February/March 2015). To access the data without downloading a dump, DBPedia offers a sparql endpoint to be called from any programming language (see more at section 4.3.1).

The FOAF (Friend of a Friend) project (Brickley and Miller, 1999) is an experimental linked information system "defining a dictionary of people-related terms that can be used in structured data". For example most of the social networks store their members' information in FOAF format including email, name or address. Golbeck and Rothstein (2008) conducted a study to identify on how many social networks a user is registered and to what degree he is related to others (represented by friendship). They could connect two networks if at least one person shared an account (e.g. by email address) on both social networks. For example 2357 users share same FOAF data on both LiveJournal blog and Tribe social network platform. But this semantic data is not only used by social networks, also DBPedia uses FOAF data as properties of a resource. To the DBPedia resource of the german chancellor 'Angela Merkel' the following FOAF properties are attached: foaf:depiction, foaf:givenName, foaf:homepage, foaf:isPrimaryTopicOf, foaf:name and foaf:surname.

GeoNames[13] is a linked dataset that provides geospatial semantic information about over eight million places in the world. Example properties attached to a city are longitude and latitude coordinates or population. GeoNames semantic data is linked to DBPedia linked dataset by most common predicates geo:lat, geo:long and geo:geometry to provide information about geo position of geographical point.

[13] http://www.geonames.org/

3 Similar Games and Model Development

With the knowledge of the last chapter about serious games, gamification and semantic web and the relevant literature, this chapters tries to develop a model that will be used for the evaluation of the thesis. For this purpose relevant studies will be summarized regarding their focus on performance, acceptance and learning effect. Performance measurement includes the stability of the game, number of calls to DBPedia and velocity of game. Acceptance means the subjective perception of the users regarding the usage of the game. It includes but is not limited to the perceived fun while playing the game and the motivation to acquire new knowledge. The third measurement can be illustrated by a learning curve and shows the change of skill of players from first to last played game. It can be evaluated for example by the percentage of right answers.

Learning and acceptance measurements are influenced mostly by game design elements (gamification). Therefore, to evaluate the different elements of the game I will use the findings of Kapp (2012) who distinguishes between structural and content gamification. There exists many different articles that used the semantic web to evaluate different metrics. Lehmann et al. (2013) used DBPedia to build a flag question game to evaluate if the link between the image of flag and geo data of country is identical. The users can verify or reject the linkage between the entities or make no decision. Furthermore, they get a different number of coins on various levels of difficulty (rewards). Thaler et al. (2011) created a game based on DBPedia thereby the players have to collaborate in a team of two to solve a series of challenges and to get points for each round. The goal of each challenge is that both players agree in the answer that a concept (e.g. film festival) is a subcategory of a specific ontology (e.g. Happening). Ketterl et al. (2011) developed a single player game called "WhoKnows?" to detect inconsistent data in DBPedia. Out of 4,051 triples played 342 triples have been identified as potentially inconsistent. The goal of the game was to answer questions right that were generated from DBpedia RDF triples. Based on their performance in the game, the players got points for a ranking list with the objective to motivate the players to perform better in the next rounds. To sum up, the game was an approach to increase the usefulness and availability of semantic data in the web by detecting inconsistent data in DBPedia. Siorpaes and Hepp (2008) created a multiplayer game where the players have to collaborate to get points for a ranking list. The goal was to confirm the ontologies attached to a wikipedia article, for example if Barack Obama has the ontology person, men and president. Steinberg and Brehm (2009) proposed in their article to use the game community to generate questions for a quiz based on semantic data. The users should therefore use the available data on the web to decide which content is useful and can be used in a game. It is an approach to achieve a semi-automatic generation of games to increase the data quality caused by outdated, inaccurate, incomplete or inconsistent data. All of these games focus on

		Gamification						
		Structural			Content			
Journal Article	Focus	Rewards	Community	Ranking	Challenge	Collaboration	Competition	Data
Lehmann et al. (2013)	Acceptance	*						*
Thaler et al. (2011)	Performance				*	*		*
Ketterl et al. (2011)	Performance	*		*				*
Siorpaes and Hepp (2008)	Performance	*		*		*		*
Steinberg and Brehm (2009)	Performance		*					*
Bratsas et al. (2012)	Learning				*	*		
Wolf et al. (2011)	Learning		*		*		*	

Table 3.1: Overview of similar games, their focus and containing game elements.

the performance of the system to verify semnatic data quality. Bratsas et al. (2012) developed an single player (students worked in team of two) educational game based on the Greek version of DBPedia thereby facts from eight different categories (geography, history, athletics, ..) were used to generate questions for the quiz. For each question a wikipedia link was presented to give the player the opportunity to learn more about the item, 56% of the students followed these links more than once. Wolf et al. (2011) crated a 'Jeopardy!' style quiz game where the players should find to the correct question to the given answer. Three players compete against each other in each round and after the correct answer was found the corresponding wikipedia article is shown to the users. A given question was for example 'This Russian philosopher was also called Vladimir Ilyich' with the correct answer 'Lenin'. The data for this quiz were retrieved from DBPedia thereby the importance of a property were calculated by the number of times it was played. Therefore, it was an approach to filter out irrelevant attributes of a resource to show only important facts to the users. All relevant studies that includes a similar game compared to this educational game are summarized in table 3.1.

To create the model we start with the classification of the game as an educational game (see section 2.2.3 about edutainment). This is based on the article by Okan (2003) who suggests to transform learning material into entertainment context. In fact all of the games in table 3.1 refers to educational games however most of the times the interest of the users in learning is used to develop game with the purpose to improve the data quality. The research in such games is necessary because the content is generated automatically using semantic data from linked data sets like DBPedia as in the 'WhoKnows?' game by Ketterl et al. (2011). The players verify the content of the questions while playing the game and therefore the usability and availability of the data can be improved. For our game it means that we want to analyze the auto-generated content in terms of performance. It includes how many games were played, usefulness and availability of the content and velocity of the data inquiry. The second layer of the model contains beside the data processing step also the game design elements which refers to gamification. As stated at the beginning of this chapter these elements will be classified along structural and content gamification (Kapp, 2012). Not all items of the list by Bunchball in section 2.3 that includes for example badges, leveling up or goals will be used in the game. We want to set the focus to the following three game elements of structural gamification: rewards, community and ranking. Rewards as points or badges are a good medium to motivate the players keep playing the game [(Ketterl et al., 2011);(Siorpaes and Hepp,

2008)]. It lies in the nature of people to be better than others and to get much rewards as possible. Examples can be found in the real world, just think about soccer tournament where the player with the most goals will get a badge or trophy. Community elements should supports the social interaction between the users. The most well-known tools are chat windows where the players can write with each other. Main features include giving the player the opportunity exchange themselves with other people about the game and to help him if he encounters a problem he cannot solve. Lee et al. (2005) stated that chat may foster student collaboration and build a sense of community as the users feel connected to others within a virtual environment. Regarding the evaluation, the community plays an important rule regarding the subjective perception of motivation and learning. The third game design element of structural gamification is ranking and means the creation of a highscore list which illustrates the performances of the users. Mostly it is based on points the players get after they finish a specific task or round thereby the amount of points is determined by the performance of the player. A sample game that include a rank for each player is the prototype 'OntoGame' by (Siorpaes and Hepp, 2008) where players get points for correct answer. In this study 15 users perceived the ranking of players displayed in the beginning of the game as a motivation to improve their skills. The problem of a ranking list is the fact that it cannot be used to illustrate the actual learning skills of the users. Good players will be ranked at the top of the list as they win more games than bad players. It would be very surprising if a player with higher percentage of won games is ranked lower than other players with worse performance. However, it is still possible to evaluate the number of correct answers based on the rank of the player.

For content gamification three elements are included: challenge, collaboration and competition. Kapp (2012) suggests starting the game with a challenge instead of a list of objectives. It is included in the model as it plays an important role before starting the game. The prototype of this thesis can be divided into two phases to get a better understanding of the concept of challenge element: warm-up phase and actual game phase. In the first phase the players are voluntary invited to look up the content of the cards by following the provided link to wikipedia pages. If either both players want to start the game or if time is running out, then the second phase will be initialized so that the game board is loaded. The idea to link articles inside the game is mainly based on the articles by Bratsas et al. (2012) and Wolf et al. (2011). The difference is the moment the information is shown as in these articles the link is provided only after the round was played and not at the start of the game. The challenge provided in the game is therefore a good opportunity to evaluate the effect of providing such wikipedia links on learning effect. Opposite to the ranking list the number of clicks on the links and the time spent reading do not automatically illustrate the skill of the player. In an optional case, good players use this tool before the game to get an competitive advantage over the opponent and therefore can improve their skill and acquire new knowledge. The other two elements of content gamification represents the type of gameplay as the player can either collaborate or compete to solve a task or challenge. In most of the games in table 3.1 the players collaborate to solve a task, for example in the experiment by Siorpaes

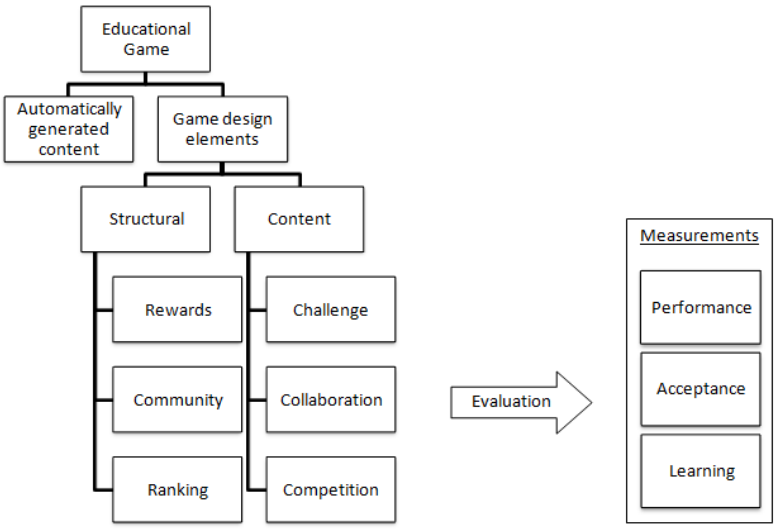

Figure 3.1: Model based on related literature

and Hepp (2008) discussed at the beginning of this section with the purpose to verify ontology links in DBPedia.

Therefore, collaboration is a great tool to improve the usability and availability of automatic generated content as at least two players have to agree with the same answer to get for example points for the round. Of course the more players work together the more likely it is that if all players agree on same answer than the data source is correct. Cunningham and Duffy (1996) suggests to learn in groups as the collaborative learning helps to promote the dialogical interchange between the users and furthermore it supports the reflectivity on the learning process. Therefore, if we want to use collaboration as a game type where the users must agree on the answer, it is necessary to combine this technique with a community tool like a chat so that the players are able to reflect their own decision and the answer given by the opponent. Instead of working together, the players can also compete against each other. In this case a player get points if he give the correct answer independent of the opponent. This mode is closer to the nature of a person to be better than others. However, the question is which of the two mode collaboration and competition affect the motivation of a player more. Abra and Abra (1999) stated that as soon as there exists neither goals nor opponents the enjoyment and interest of the participants decrease. This contradicts the statement quoted by Kohn who claimed that motivation does not decrease when cooperation replaces competition. The question remains when both modes occur in the game, which make the two options to the user more fun, motivating him more and possibly positively influences its ability to learn and to improve his skills.

To sum up, all of the different game design elements will be evaluated regarding the performance of the game, the acceptance of the players including the influence on their motivation and the influence of the elements on the learning skills of the users. The finalized model is illustrated in figure 3.1.

4 Prototype

In the following chapter the prototype of this thesis will be described in detail to gain a basis for the results after testing and deployment of the game. First the main idea of the game will be described before the the general architecture is shown which was used to host the application. Afterwards the main development steps are shown inclusive data preprocessing, user interface, testing and deployment.

4.1 Idea

The idea of this prototype is to create a game for entertainment, education and data improvement. The players should have fun playing the game and be motivated to keep playing. The data for the cards should be retrieved automatically from the linked dataset DBPedia. Therefore it is possible to generate thousands of different topics and cards without any user who has to enter them manually. Compared to manually generated content it is much more scalable because thousand of new Wikipedia articles are published every year and it is possible to include other data sources than DBPedia. The disadvantage is that the data is not verified by a user, therefore there might be some wrong data based on inconsistency or old data. The game is divided into a warm-up phase and the actual game phase. As described at the beginning of this thesis, the players have the ability to inform themselves about the playing cards in the game by following the Wikipedia link of the card. The idea behind this implementation is to analyse the effect on rank of players and therefore the learning skills of the player.

The first idea for the game phase was a mix of 'Trivial Pursuit' and 'Top Trumps'. That means numerical values can be played directly against each other and nominal values are used to generate questions. But some problems occurred during development which made it impossible to use numerical values as a basis for the game. There exists for example over 20 different currencies in the whole dataset. In that case it would not be possible to play the values directly against each other as they do not share the same metric. Additionally, as DBPedia is updated only once a year, values shown

The reason to include both games in the prototype is the missing ability to compare non numerical text based on the value as there exists no greater or smaller reference. For this purpose we use the rules of 'Trivial Pursuit' to generate questions that must be answered by the opponent player. Therefore each card contains both numerical and nominal properties although only the numerical values can be played against each other. If the property contains a nominal value a question is generated with the right answer and three additional alternatives which are retrieved from other resources of same topic. The game let the player choose the wrong answers to make it more interactive as otherwise it would be just a 'pick a card' game.

To sum up, we want to analyse three things. First the performance of the game is checked and evaluated to measure the usefulness and availability of the data. Second we want to analyse how the players perceive the game features regarding fun and motivation. Third it is essential to test if the game can be used as a prototype for further educational games. In this case it must have a positive learning effect for the users.

4.2 Architecture

In this section SmartFoxServer 2X (SFS2X) a middleware solution for the communication between client and server will be described. The client side files are hosted on Uberspace, the server on an Amazon Elastic Compute Cloud Server.

4.2.1 SmartFoxServer

As the game is developed as a client server application there was the need for a middleware solution to handle game requests and send data back to client. There exists many solutions on the market to build a client-server architecture, for this thesis I looked into the solutions of Photon and SmartFoxServer and in the end I chose the second approach. The main reason for this step was that Photon Turnbased SDK limits the total number of people allowed at the same time on the free tier to 20 concurrent users (CCU) per application. 100 CCU would costs a 65 USD one time fee but compared to SmartFoxServer this solution starts with 100 CCU for free. An additional advantage of SmartFoxServer is the possibility of an elastic license, that means that you can expand the maximum concurrent users for a price of 0.05 EUR per CCU per month. SmartFoxServer offers three different editions of the server: Basic, Pro and 2X. The difference between the editions are the total number of features[1] available. So for the basic version it is for example not possible to write server-side extensions, but that is a core function of the prototype. In the end I have chosen SmartFoxServer 2X (Community Edition v2.9) as this is the only edition that supports HTML5 on the client side. Version 2.9. only supports Java SDK 7 therefore every library attached to the server must be written for Java SDK 7 and not the newer version 8. Beside HTML5 several other SDKs are supported: Flash, Unity or Java. I decided to use the first mentioned SDK as the main goal was to develop a cross-platform game that is independent of the operating system. Thus the user do not have to download any software to test the game, that is a big advantage as many people may not trust downloads from an unknown source. Another possibility was the development with the Adobe Flash SDK but security issues leads towards the decision to HTML5 framework. Beside the limitation of 100 CCU in the free version, there exists a limitation by the elements used. The SmartFoxServer API for HTML5 requires websocket support (persistent connection between client and server) and the user interface is based on canvas technology. As a consequence Internet Explorer browser is for example supported from version 10.0 as prior to this version websocket is not supported. Global

[1] http://www.smartfoxserver.com/products

browser support for the prototype is about 90% that means 9 out of 10 users can play and test the game.

The architecture of SFS2X consists of n zones that contains m rooms. So the total number of rooms that must be managed by the server are $n * m$. Users connect and login to exactly one zone (see figure 4.1) and on successful action they are forwarded to a specific room (e.g. lobby of game).

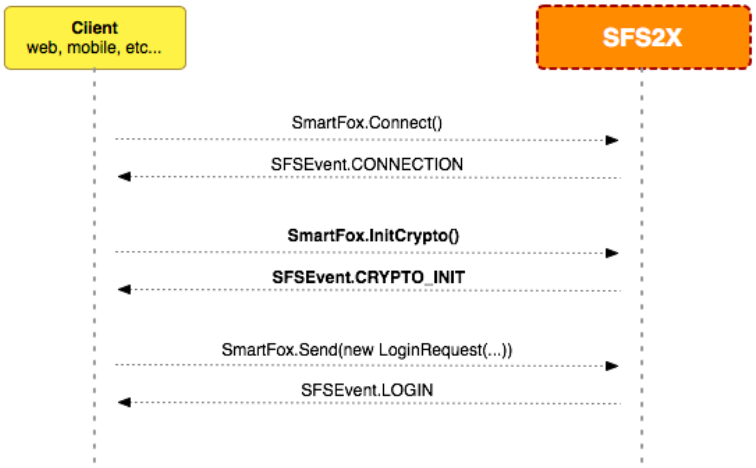

Figure 4.1: Simplified connection process between client and server.[2]

With that architecture it is possible to differ between different types of users (e.g. nationality), but for simplicity only one main zone was used. The SFS2X server for this thesis contains two zones: (1) EduGame: lobby and all game rooms and (2) Registration: zone to handle sign up requests. The registration zone is a dummy zone that contains no rooms. It is needed as for registration of new users a login request must be sent to the server. But as the 'EduGame' zone requires login credentials it would not be possible to have login and sign up procedures in the same zone. The zone 'EduGame' contains one default room named 'Lobby' that is used to show a lobby window to the users prior to starting a game. For each new game request sent by a user a new room is created in this zone.

Besides the client side implementation there is the need for server side code to handle the game logic. For this purpose it is possible to include server-side extensions (Java code) to a zone and room respectively. SFS2X provides two ready-to-use Java classes 'SignUpAssistantComponent' and 'LoginAssistantComponent' which contain customizable functions for login and sign up requests. Therefore one extension is attached to the 'Registration' zone to add users to the database and another one is used for the 'EduGame' zone to check login credentials against the database. This extension also contains the logic to create a new room. Although it is possible to create a room on

[2] http://docs2x.smartfoxserver.com/_documents/GettingStarted/_images/cryptoflow.png

client-side, room variables (e.g. difficulty level) can be set to be accessible by all users only on server-side. A third extension is attached to each room once created to handle sparql requests to dbpedia and to execute game logic.

4.2.2 Hosting client and server files

The hosting provider Uberspace[3] is used to publish the client files on the web. The main reason for this hosting solution was the easy setup, cheap and advertisement free presentation of content. It offers several functions that would be useful (e.g. MySQL database) but as no external access to the database is allowed it is not possible to setup the databases for SFS2X server on Uberspace. This is because the SFS2X server was set up on Amazon Elastic Compute Cloud (EC2) and database settings are included in the server itself.

Amazon EC2 is a web-service that offers the possibility to setup a server in their cloud. The advantage is that you don't have to maintain hardware for the server and the system is very flexible and scalable if requirements are changing. It is possible to choose between different types of Windows and Linux servers and the main memory needed to deploy the server. The pricing for the server follows an on-demand principle so that users pay per instance and hour. For example a t2.micro instance (1 GB RAM) with an Ubuntu server running would costs 0.013 USD per hour plus 0.09 USD per GB outgoing data. Amazon also offers a free tier with no costs for a t2.micro instance for one year except outgoing traffic over 1 GB. This should be enough as no heavy usage of the server is expected. For the prototype a t2.micro instance was set up under the free tier with an Amazon Linux AMI (Amazon Machine Image) 2015. It contains an Apache HTTP Server Version 2.4 with an MySQL installation. It contains the SFS2X server instance for the communication between client and server and additionally a MySQL database was set up to store user data and everything that has to be recorded for evaluation.

4.3 Development

In this sections the main development steps are described. That includes the data preprocessing to eliminate useless data. For example if a topic does not contain at least a minimum number of distinct items it will be excluded from the topic list showed to the user. Additionally, the user interface of the lobby and game board will be described to get an understanding how the game looks like. The different steps how to create a new room in the game and the game logic are characterized in the following section. The last two sections deals with the deployment of the game, this includes also the creation of the survey to evaluate the subjective perception of the players regarding the usage of the game.

[3] https://uberspace.de/

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl:  <http://www.w3.org/2002/07/owl#>

SELECT ?uri ?category ?label WHERE {
   ?uri rdf:type owl:Class
   bind(strafter(str(?uri),'http://dbpedia.org/ontology/') as ?category)
   ?uri rdfs:label ?label .
   FILTER (LANG(?label)='en')
}
```

Figure 4.2: Retrieving categories from DBPedia

4.3.1 Data Retrieval And Preprocessing

The data for the prototype is retrieved from DBPedia inside the server-side extension of SFS2X. For this purpose the Apache Jena libraries are used in Java. Apache Jena is a semantic web framework that provides an API for Java to create and read Resource Description Framework (RDF) graphs (Jena, 2015). The newest Jena version at time of development was 3.0.0 for Java 8 support only. As SFS2X extensions only support Java 7 libraries the older Jena version 2.13.0 was used for the project. The results returned from DBPedia can then be formatted as JSON and sent back to client to display the found RDF tuples to the user or stored on the server for the game.

The DBPedia endpoint which is called from Apache Jena library consists of the endpoint 'http://dbpedia.org/sparql' and the default graph uri 'http://dbpedia.org' to retrieve the main source of RDF triples. If the properties of DBPedia should be limit to the German DBPedia the language prefix 'de' must be attached prior to dbpedia string. As the content of the educational game should not be limited to any foreign language other than English it is important to use the default graph uri. To retrieve the rdfs:label in English language we filter the results by using *'filter langMatches(lang(?name), "EN")'* operator whereby ?name is the variable for the rdfs:label. This is an important preprocessing step as otherwise the same RDF triple would be returned in all languages found resulting in duplicates of results.

The data is retrieved in three steps, each of them representing a different level of aggregation. On the top level all entities are aggregated to distinct categories to give the user the opportunity to select a specific category he is interested in. The problem was to find categories that are not too specific to reduce the choices for the user on the top level. In DBPedia there exists many links to other semantic web datasets like Yago but the problem is that the classes found in Yago are already too specific. So for example if the user wants to retrieve all categories assigned to the resource 'Lufthansa' many Yago categories would be found like 'CompaniesBasedInCologne'. This maybe a good topic on second level but way too specific for top level. Therefore only ontologies are considered with the uri '<http://dbpedia.org/ontology/>' (=dbo, see figure 4.2 for query). The query runs only for a few seconds to retrieve all ontologies from DBPedia.

This leads to 735 distinct categories on the top level, but not all of them are useful as they may not have at least the required number of cards of the same category. Further-

```
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX dbo:<http://dbpedia.org/ontology/>
PREFIX vrank:<http://purl.org/voc/vrank#>
PREFIX dct:<http://purl.org/dc/terms/>
SELECT DISTINCT ?uri (COUNT(DISTINCT ?s) AS ?count) (SUM(DISTINCT ?v)/COUNT(DISTINCT ?s) AS ?popularity)
FROM <http://dbpedia.org>
FROM <http://people.aifb.kit.edu/ath/#DBpedia_PageRank>
WHERE {
?s dct:subject ?uri.
?s rdf:type ?type.
filter (strstarts( str(?type), 'http://dbpedia.org/class/yago/Politician1' ) ||
    strstarts( str(?type), 'http://dbpedia.org/ontology/Politician' ))
?s vrank:hasRank/vrank:rankValue ?v.
FILTER(?v >= 10)
}
GROUP BY ?uri
HAVING (COUNT(DISTINCT ?s) > 9)
ORDER BY DESC(?popularity)
LIMIT 20
```

Figure 4.3: Retrieving topics from DBPedia: Example for ontology 'Politician'

more the assigned ontologies are not consistent for similar resources. While for example the resource for the german ice hockey team 'Starbulls Rosenheim'[4] contains the right ontology 'dbo:HockeyTeam', the ontology is missing for the team 'Adler Mannheim'[5]. But at the same time both teams has the Yago class 'yago:HockeyTeam108080386'. Therefore, to solve this inconsistency and to find all resources both datasets are combined for the next level to find topics for each category. This idea of merging the two datasets is mainly based on the article by Bizer et al. (2009) who wrote a script to assign Yago classes to DBpedia entities (no longer available).

The second level represents the topics assigned to the categories on the first level. In DBPedia topics are represented by the prefix '<http://purl.org/dc/terms/>' (=dct) and the property 'subject' (dct:subject). So for example the german airline 'Lufthansa' has 11 different subjects assigned: Airline holding companies, Airlines established in 1953, Companies based in Cologne, Holding companies of Germany, Association of European Airlines members, Companies listed on the Pink Sheets, German brands, IATA members, Airlines of Germany, Lufthansa and Star Alliance. However, as more than one topic can be assigned to a subject, the same card can be played for different topics. At least one topic has to be assigned to a category so that it is visible in the list. To reduce the maximum dataset and to speed up the game creation process later, only 20 topics per category were retrieved. This is necessary because there exists categories on the first level with more than 100 assigned topics. Furthermore it is required that a topic has at least 10 resources assigned with the same topic thereby only resources with a PageRank of at least 10 are included.

In DBPedia Thalhammer (2016) computes annually a PageRank for each resource based on the property 'dbo:wikiPageWikiLink' to spot the importance of a resource in the dataset of DBPedia. It must be noticed that a PageRank can be as low as 0.1 thereby

[4]http://dbpedia.org/page/Starbulls_Rosenheim
[5]http://dbpedia.org/page/Adler_Mannheim

```
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX dbo:<http://dbpedia.org/ontology/>
PREFIX vrank:<http://purl.org/voc/vrank#>
PREFIX dct:<http://purl.org/dc/terms/>
PREFIX rdfs:<http://www.w3.org/2000/01/rdf-schema#>
PREFIX foaf:<http://xmlns.com/foaf/0.1/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT ?uri ?label ?wikipedia ?rank
FROM <http://dbpedia.org>
FROM <http://people.aifb.kit.edu/ath/#DBpedia_PageRank>
WHERE {
  ?uri dct:subject dbc:Democratic_Party_Presidents_of_the_United_States.
  ?uri rdfs:label ?label
  filter langMatches( lang(?label), 'EN' )
  ?uri foaf:isPrimaryTopicOf ?wikipedia .
  ?uri rdf:type ?type.
  filter (strstarts( str(?type), 'http://dbpedia.org/class/yago/Politician' ) ||
          strstarts( str(?type), 'http://dbpedia.org/ontology/Politician' ))
  ?uri vrank:hasRank/vrank:rankValue ?rank.
  FILTER(?rank >= 10)
}
```

Figure 4.4: Retrieving resources from DBPedia: Example for ontology 'Politician' and topic 'Demctraic Party Presidents of the United States'

where exists no upper limit for the rank. This PageRank implementation is used in the sparql query (see figure 4.3) to measure the average importance of a topic based on all resources that have this specific topic assigned. Therefore it is possible to find the 20 most important topics of a category by sorting the found topics by their average PageRank. PageRank is also a great tool to implement different levels of difficulty (section 4.3.3). As the script has to run for each category one by one, the whole process takes about 70 minutes to retrieve all topics from DBPedia. All topics are also stored in the same database as the categories.

To be completely independent from DBPedia all resources of the topics are retrieved and stored in the database. The reason for this step is the low availability of DBPedia during development as the dataset and web page of DBPedia often cannot be accessed. While this is pretty bad in development phase, a downtime of the data source during gameplay would be critical for the usability of the game. Therefore, in a third query, all resources of the topics are retrieved once from DBPedia via Apache Jena library in Java (see figure 4.4 .

The number of calls to the endpoint depends on the number of topics retrieved in the last step. So while it only takes 10 minutes to get these data, removing the limitation of 20 topics per category results in a longer process to retrieve the resources. For this sparql request the limitations of the previous queries are used, namely that a resource must have at least a PageRank of 10. As a result 15,777 resources are returned from DBPedia, thereby each resource represents one card that can be played in the game. As

```
PREFIX dbr: <http://dbpedia.org/resource/>
SELECT *
{
dbr:Barack_Obama ?p ?o
FILTER(STRSTARTS(str(?p), 'http://dbpedia.org/ontology/'))
FILTER (!regex(str(?p), 'http://dbpedia.org/ontology/abstract','i'))
}
```

Figure 4.5: Retrieving properties from DBPedia: Example for resource 'Barack Obama'

a resource can be assigned to multiple topics, only 7,278 distinct resources are stored in the database. Removing the limitation to a maximum of 20 topics per category would results of course in a much larger dataset.

As the properties of the resources are used in the game as data source for the questions, a fourth sparql query is executed to retrieve all properties. There exists many different types of properties with different prefixes, but the most robust and high-quality property seems to be the ontology one. It has the same prefix as the category (dbo) as both are maintained manually and therefore fault or nonsensical data is excluded from this property type. In a first attempt all properties with the prefix 'dbp' were retrieved but this led to a huge amount of data (514,344 rows respectively 32.6 properties/card). Both prefixes represents among others the information box on the top right corner of Wikipedia. While the ontology properties are limited to this box, the other one also contains data of the whole article outside the box. This results in useless weather data or geo data attributes, both cannot be used as data source for the questions. Limit the properties to only ontology prefix results in about the half of properties returned from DBPedia (277,188 rows). The whole process takes about 25 minutes to retrieve all properties from DBPedia. The problem is that even though a thumbnail link is included in the result set, it cannot be used to illustrate the resource in the game. This is caused by security conflicts between the framework used for the game and the terms and conditions of Wikipedia Commons which restrict anonymous access to their images. As a consequence an additional request must be sent to the Wikipedia API[6] to get a link to the main image of the article. These images does not include these security restrictions and can therefore be stored in the database. About 40 minutes must be considered when retrieving all image links.

The data retrieval process is completed after this step and all data is stored in the database. The whole process takes about 140 minutes to retrieve all data from DBPedia with Apache Jena Library. The main problem with this solution is the large amount of calls to the sparql endpoint, therefore it seems reasonable to download a copy of the DBPedia dataset. That is even more important when the number of topics is expanded and less known resources with as lower PageRank are included (resulting in larger dataset).

But not all properties and resources can be used from the dataset stored in the database. The main problems are but are not limited to

- Redundant and wrong data

[6] https://en.wikipedia.org/w/api.php?action=query&titles=XXX&prop=pageimages...

- Resource does not have at least a minimum number of properties assigned
- Properties with multiple values
- Properties only occurs in few resources, therefore no answer options can be created for the question
- Useless data like id fields
- Values returned in wrong data format and must first be converted to right metric

As a consequence these properties must be deleted in the database, but as every deletion of a record also influences other conditions that must be fulfilled, this must be done incrementally (see figure 4.6). So for example if there are too few properties of the same type the associated resource must be deleted. As a consequence it must be checked if there are enough resources left of the topic associated with the deleted resource. If not, delete all resources for this topic and thus also their properties and start again. After applying the filter to the data 78 categories, 662 topics, 4,277 resources and 914 properties (all distinct values) remain in the dataset and therefore can be used as the maximum dataset for the game.

However, as the number of users are limited to test the game, only a subset of the data is used for the game (distinct): 28 categories, 30 topics, 298 cards and 217 properties. The chosen categories and topics are shown in table 5.1. However they were not chosen randomly, but based on the average PageRank (about 108) of the whole dataset and the average PageRank of all topics in same category. The resulting dataset is a good mix of well known and quite unknown resources and therefore it is possible to establish different levels of difficulty based on the PageRank.

4.3.2 User Interface

Four main windows were created for the user interface: sign up, login, lobby and game window. The first two frames were constructed to make it possible to identify a user but they contain no game logic. It would be technically also possibly to login as a guest but in that case it is not possible to re-login with the same username after leaving the game. Users who wanted to sign up for the game had to accept some terms and conditions to clarify that their interactions are tracked during the game. An abuse of the system was prevented by the CAPTCHA technology of Google. The lobby interface (figure 4.7) includes four elements: chat window, ranking list, room and user overview. The elements of the lobby were created with the help of jQuery, jQWidgets and css. jQWidgets is a library that provides ready-to-use widgets for the usage in web applications. The lobby is a room where all players are forwarded after login and after the game ends where they have played a game. The ranking list and badges exists mainly for motivation purposes so that the players keep playing because they want to level up (see more at gamification in section 2.3).

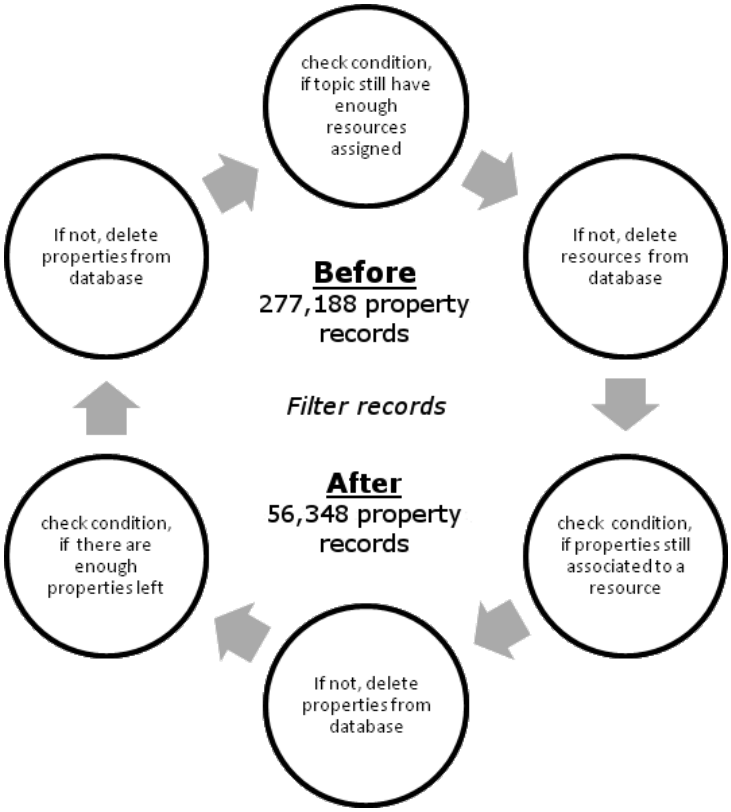

Figure 4.6: Incremental Delete of properties and resources from database

The gameboard was created with the JavaScript library CreateJS[7] to draw all game elements (cards, player names, ..) on the board. It is not only used to flip and move the cards over the board, but also to build a new card in case a question is requested. The card itself contains all elements of the database record, that includes the category, topic, resource name and four distinct properties.

4.3.3 Game Logic

A game always consists of three card stacks with 6 cards each thereby each stack represents one topic which was chosen before the game. There exists one singleplayer game mode where the user selects one topic and the other two are randomly added by the computer. The multiplayer game modes are designed for two persons thereby each of them selects one topic from different categories. The third topic is added automatically.

If a user creates a new room he is moved forwards to a room where he can get information about the cards in the game by opening the associated wikipedia links.

If the user creates a room he has to wait for an opponent and if both are ready the game switches to warm-up phase. Where both players have 3 minutes time to

[7] http://www.createjs.com/easeljs

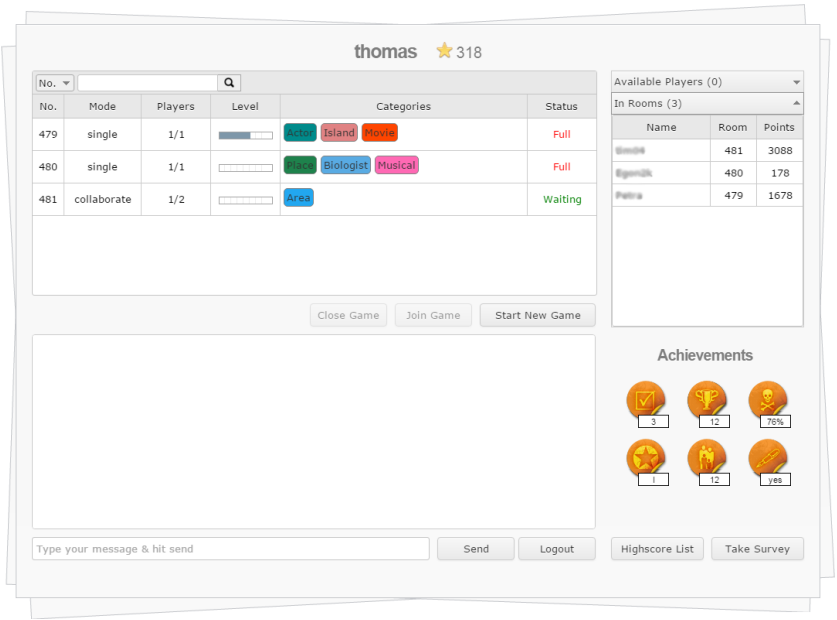

Figure 4.7: Lobby design in the game

inform themselves about the cards that will be played in the game thereby they have the opportunity to leave this phase early if both wants to start the game. The game is a turn-based card game, the player who has the turn flip a card of the stack and choose the property for the creation of the question. If the value is either an integer or a date, then he can play this card directly against the opponent by the rules of 'Top Trumps'. The user has to decide about the strength of his card and based on his decision either the higher or lower value wins. If the value is a nominal value, then four answer options are created including the right value of the property. To make the game more interactive and game-like, the wrong answers can be chosen by the user. Afterwards the card including the question is sent to the opponent player who has to give the right answer. If the answer is correct, then the card moves to his card stack. In case all cards of the same topic are inside one stack, these cards cannot played longer as they are removed from the game. However, if the answer is wrong, then the card moves back to the stack of the opponent. A player wins the game if he either owns all cards or the time runs up. The winning user get rewarded with points and both player are forwarded back to the lobby.

A player can also choose the other mode to collaborate with his opponent to win the game. In this case the player choose also a difficulty level and the category he wants to play with. The difference to the other mode is that there are no more steps to select topics or even cards. 30 cards are created based on the chosen categories thereby the player does not know which cards are included in the game. As with the other other mode, the players are given the possibility to get familiar with the cards. Once the game has begun, both players are asked to guess the correct value on the card in each round. If both give the correct answer, then both get a point. If one or both gets wrong, none

of them get rewarded. Based on a scale from 0 to 30 right (shared) answers the players get points to their accounts and forwarded back to lobby.

The game room will be destroyed once the game has ended and the players can either create or join a room or stay in the lobby.

The warm-up interface is loaded after the game was created to provide a link to Wikipedia for each card. If the second player joined the room, next they have 3 minutes to inform themselves about the cards which are played in the round. To illustrate the content we have chosen to use the mobile version of Wikipedia as it concentrate on the main facts at the top of the page. In the retrieved results from DBPedia also a link is send to the server that contains a picture of the resource in Wikipedia. However it can not be used to display the image on card because there is a conflict with HTML5 technology. Therefore it is necessary to additionally call the Wikipedia API[8] to get an image for card. The reason is that the canvas library used to draw the game board requires an anonymous access on image URL while Wikipedia Commons where it is stored forbid this type of access. By using both services DBPedia and Wikipedia it is now possible to create a playing card with some properties and an image.

4.3.4 Generate Questions In Game

One important question when designing a game is how to implement different levels of difficulty into the game. Most games on the market use a fixed system where the player selects a particular level at the beginning of the game (e.g. "Easy", "Medium" and "Hard"). The advantage is that it is easy to integrate into the game and the player knows exactly how hard the game will be played on each level. On the other hand it cannot react to changes in the gameplay, for example if the players performance is better than expected than the game will not get automatically harder. The sole solution in this situation is either change the level if possible or restar the game.

4.3.5 Survey and Deployment

To evaluate the subjective perception of the users towards the usage of the game, a survey was constructed with SurveyGizmo[9]. The free student versions allows 500 responses per month, but for the purpose of this master thesis that is sufficient. They were asked the following questions:

1. How do you rate the difficulty of the game?
2. How would you rate the data quality of the games?
3. Was it fun to play the games?
4. Would you play it again?
5. The game has a user friendly interface.

[8] https://en.wikipedia.org/w/api.php
[9] www.surveygizmo.com

6. Did the Wikipedia Links in the Warm Up Phase influence your decision to play the game or not?
7. How important were the links regarding your answer on questions?
8. Did the badges in the game influence your decision to play the game or not?
9. On a scale of 1-100, with 1 being “poor”, how do you rate the game?
10. My knowledge and skills enhanced through playing the game. (asked after the game ends)

The estimated length reported by SurveyGizmo was three minutes compared with my personal length of two minutes. Additionally two persons were asked to fill out the survey with test data to estimate the predicted time needed for the users. The two persons needed two and four minutes thereby the time depends how fast they clicked through the survey. Therefore the average time to complete the survey lies between two and four minutes. The users were additionally shown the first question which they answered wrong in the game when they opened the survey.

The game that includes a link to the survey was published on several online game communities to reach plenty of gamers who are familiar with games. An alternative would have been publishing the survey and game on the crowd sourcing platform ’Amazon Mechanical Turk’ where users getting paid to fulfill micro tasks. The problem is that the users get paid per task which last normally only for a few minutes. The educational game requires players to play at least 3 or more games to recognize a major change in learning. As the income per hour is around $8, it would costs too much money to publish the game on this platform. Furthermore, the players might not be motivated to really learn something as they get their money anyways. Therefore the better solution is to distribute the game in online communities. The idea was to create a lottery with fixed prices for the first three places and ten random small coupons that are distributed under all players. To participate in the lottery the players have to play at least 3 games and fill out the survey.

The game were published on January 25th, 2016 for 2 days under the german title ’Masterarbeit: Brauche eure Hilfe zum Testen meines Spiels -> Verlose Amazon Gutscheine’ on the online community MyDealz[10] and additionally one day later on the gamer platform spieleforum[11]. Furthermore some players were invited over Facebook to join the game.

The game and corresponding survey were accessible from January 31th, 2016 9 PM to February 2nd, 2016 11 PM.

[10] www.mydealz.de
[11] www.spieleforum.de

5 Experimental Results

In this section the main results will be shown, that includes information about the players and the gameplay. First of all the performance of the game will be analyzed before the results of the survey will be shown. The findings regarding learning are described in the last section.

5.1 Performance

During the two days where the game was opened to the public 63 people created a new account for the game, thereby 61 of them answered at least one question in the game. The interest in the game was high at the beginning of the distribution phase and dropped over time. A maximum of 13 players were online at the same time.

629 game rooms were opened thereby only 545 of them were started. The main reason why a game was closed was the missing number of players in the multiplayer mode. The started games are unequally distributed over 527 singleplayer and only 18 multiplayer games (12 collaboration and 6 compete mode).

5.2 Acceptance

The users were asked to fill out a survey how they perceive the game. Most of the questions are based on the survey layout by Siorpaes and Hepp (2008) where the players were asked how they like his game (questions

5.3 Learning Effect

A possible learning effect by playing the game were measured at multiple points. During the whole game links to Wikipedia were provided so that the user could get more information about the content of the game. Table 5.2 gives an overview about the number of clicks on Wikipedia links and their duration of it is stored in the database.

category	topic	PageRank	Cards	# Player	# Auto	# Total
Place	Germanic Countries And Territories	1056.45	13	43	74	117
Place	Eastern Europe	989.19	7	38	78	116
Area	Capitals In North America	178.8	13	95	93	188
Island	Islands Of Africa	128.61	6	6	52	58
Capital	University Towns In Germany	100.48	10	69	97	166
Person	16th-century English Writers	81.76	13	3	42	45
Aristocrat	18th-century Monarchs In Europe	58.74	14	41	89	130
Philosopher	17th-century Philosophers	55.96	9	3	47	50
Artist	HIV/AIDS Activists	54.35	9	8	46	54
Legislature	State Lower Houses In The United States	20.39	20	2	6	8
School	Schools Of Public Health In The United States	58.73	9	0	13	13
Soccer Club	Copa Del Rey Winners	42.75	9	8	20	28
Soccer Club	Scottish League Cup Winners	32.17	9	3	19	22
Actor	American Businesspeople In Retailing	40.43	11	95	24	119
Record Label	British Record Labels	40.83	6	0	16	16
Cleric	Roman Catholic Mariology	68.03	8	11	32	43
Political Party	Eurosceptic Parties	22.78	14	11	17	28
Town	Seaside Resorts In England	32.09	9	1	36	37
Dancer	American Male Film Actors	36.87	11	2	29	31
Biologist	Members Of The French Academy Of Sciences	36.08	10	4	30	34
Guitarist	American Folk Guitarists	33.07	12	0	25	25
Mammal	Mammals Of South America	37.74	7	3	7	10
Athlete	European Footballer Of The Year Winners	18.76	9	163	29	192
Musical	21st-century Classical Composers	31.94	10	1	46	47
Journalist	21st-century American Writers	19.61	9	2	26	28
Drug	Phenols	30.59	8	3	15	18
Movie	Science Fiction War Films	22.07	10	2	12	14
Comedian	American Film Producers	17.16	14	1	48	49
Tennis Player	Medalists At The 2008 Summer Olympics	18.19	12	3	36	39
Contest	Game Boy Advance Games	14.34	8	17	15	32
		112.63	10.3	638	1119	1757

Table 5.1: Chosen topics by players and automatic (ordered by PageRank)

Point of Time	Clicks	Duration (sec)
Warm-Up Phase	431	13.26
After Each Round	33	
After Game Ends	3	
At Game Creation	2	

Table 5.2: Number of Clicks on Wikipedia Links provided during the game

6 Discussion

6.1 Influence of gamification elements

6.2 ...

7 Conclusion and Future Work

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Mannheim, February 4, 2016

Thomas Kutschker