Alexander Schwaiger, BSc

German Language Training Apps for Primary School Children

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Danksagung

Die Zeit ist wie im Flug vergangen. Kaum zu glauben, dass dieses Kapitel nun zu einem Ende findet.
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Abstract

Mobile apps and the gaming industry experienced continuous growth and popularity over the last couple of years. While children have always played games for fun, researchers, recognized the promising possibilities behind games in the field of education. As nowadays nearly every child is in possession of a mobile device, the sector of digital game-based learning is of special interest and is considered as a key trend in the future among researchers. Moreover, the traditional way of learning via textbooks is not sufficient any more as growing children demand information in new ways. The ability to access information at any time and anywhere has become ubiquitous. Primary school pupils often experience difficulties when it comes to the acquisition of good language skills. Thence this thesis deals with the creation of a prototype for tablets to support German language training within primary schools. A connection to the IDeRBlog platform was established in order to make use of an intelligent dictionary that already specializes in the improvement of writing skills among children. For the evaluation, a field test among children in Austria was conducted in order to see whether educational benefits could be observed. The extremely positive field test strengthened our approach and further motivated the participants to play the game even after the test was finished. As a couple of thousand answers were submitted in a extremely short period of time, a huge amount of data could be collected and sent to the IDeRBlog for further analysis. The inter-exchange of both systems was identified as extremely valuable as Learning Analytics profit from the new sets of data and performance and accuracy improvements of the platform can be realized.

Contents

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1 Introduction [1]

The Digital Age has widely spread across the world. The 2012 Horizon Report on Higher Education (Johnson et al., 2013) described mobile apps and tablet computing as near-term horizon trends, which will become extremely important for education in the upcoming years. Especially, the growth of mobile apps is above-average in the field of higher education (Johnson et al., 2013). This supports the key trend: People consider the ability to learn, access information, study, or work without any timely or local restriction ubiquitous (Johnson et al., 2013). The gaming industry as well experienced huge growth over the last decade. The global game market is expected to generate revenues of $108.9 billions in 2017, whereas the mobile sector (including smartphone and tablet games) will gain an astonishing 42% of total revenue (McDonald, 2017).
Today's students are used to be surrounded by numerous technologies and have access to the internet any time anywhere (W. Nagler, M. Ebner, and M. Schön, 2017). While it is obvious that the world is in a process of adoption, one has to ask if the way of teaching and studying is still effective enough. By making use of Web 2.0 technologies, this already began to change in a meaningful way (O'Reilly, n.d.). Latest research in Technology Enhanced Learning (TEL) provides guidance and approaches regarding how to use technology for the education of today's students called seamless learning (Şad and Martin Ebner, 2017). While personalized learning will be crucial in the future, universities and schools will need to deal with several challenges. Nearly every institution is forced to cut costs and reduce the number of employees. Still, better services and higher quality is demanded which

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generates economic pressure and the creation of new educational methods (Johnson et al., 2013).

So far, games have been predominantly seen as entertainment and pastime. While researchers see games in education as path-breaking, strangely, there is not much to find about the actual use of digital games yet. Nevertheless, researchers started to recognize the value for science and education behind successful commercial games. James Paul Gee (2005) from the University of Wisconsin-Madison was one of the first to pay attention to the field of Digital Game-Based Learning (DGBL). Gee noticed, that researchers, teachers, and even families could benefit from learning with commercial games by applying the underlying game study principles to universities, schools and even homes. Furthermore, the derived learning principles of successful games are supported by research in cognitive science as well (Gee, 2003). DGBL is strongly connected to Problem-Based Learning (PBL). PBL describes the deployment of a specific problem in a so-called "play framework" which then needs to be solved. Although generalization cannot take place, a distinction between "normal" and high-quality games must be made. High-quality games enable players to be producers instead of only consumers, which is one of the key differences regarding the current systems/methods of teaching. This particular method of learning is called Empowered Learning and requires players to act and make decisions based on their feelings, resulting in the creation of different paths throughout the game (Gee, 2005).

The demand for better and more effective learning is ubiquitous and will shape the future of the world as we know it. For that very reason it is important to recognize, that personalized learning will help to optimize the learning potential of every individual in a significant way and refocus the field of learning (Song, Wong, and Looi, 2012). The process of learning and collecting data in order to personalize and improve the study experience has become crucial. LA have been an emerging field of science. George Siemens and Phil Long stated that "the most dramatic factor shaping the future of higher education is something that we can't actually touch or see: big data and analytics" (Siemens and Long, 2011). The need to support individual learning and offer more precise tools for education has gained a lot of attraction in science lately. Learning Analytics are about learning

and analyzing the digital footprint of each user in order to identify learning patterns. Gašević, Dawson, and Siemens (Gašević, Dawson, and Siemens, 2015) define Learning Analytics as the ”measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs”.

Back in 2012, the NMC (New Media Consortium) Horizon Report described Game-based Learning and Learning Analytics as upcoming technology trends which will experience a lot of attention in the upcoming years (Johnson et al., 2013). George Siemens stated that ”the results of Learning Analytics are potentially transformative to all levels of today’s education system” (Siemens, 2012a).

Considering DGBL and LA, it is quite obvious that education already started to change. Moreover, the way of learning will be personalized and tailored to the needs of every individual. Graz University of Technology already made use of the advantage of digitization by developing an app that supports students in studying the multiplication table in mathematics. LA have been used to gather data and see how each child deals with the challenge of learning to multiply. The conclusion of the paper states that ”automated precise testing and feedback can be seen as an individual assistance and an effort to an effective learning process” (Martin Ebner and Martin Schön, 2013).

Despite the importance of mathematics, the ability to read and write is equally significant in growing up. Good writing and reading skills are indispensable for society as they are instruments which are used in a person’s daily life. Therefore, a platform for teaching writing skills has been created by Graz University of Technology. Children in primary schools are given the ability to create and upload texts based on certain themes or experiences they deal with every day. A specific dictionary then checks for frequent spelling mistakes in the text and confronts children with it. As teachers are confronted with the individual results, they are able to support every child, and therefore improve the learning approach in a significant and personalized way (Markus Ebner, Edtstadler, and Martin Ebner, 2017).

This thesis discusses the difficulties by creating a German language training app for primary school children. Furthermore, it displays the challenges of using digital game-based learning in order to improve writing and reading skills. How shall a game be designed in order to keep children motivated while preserving the feeling of playing a game? Which types of exercises have to be created in order to support the use of Learning Analytics? Furthermore, the challenge of providing each individual child with personalized content is of special interest. Children at the age of 8 to 12 heavily vary in their available vocabulary, which makes it necessary to deliver appropriate exercise data to support targeted learning.

1.1 Structure

The structure of this thesis is split into various parts. The first main section will deal with the research field of digital game-based learning and why it might be a promising concept for education in the future. In the beginning the process of learning and cognitive benefits of games will be described. Afterwards the potentials of good learning systems are laid out. A look into games within education and especially how these can be implemented within educational contexts is provided as well.

The second chapter will give attention to the research field of Learning Analytics. The delivery of personalized content is becoming more and more important. It is crucial to understand how the process of learning works and how progress can be measured. Therefore the benefits for education need to be examined to identify how children can be supported in the best possible way.

Subsequently, the development of a German language training prototype for primary school children in Austria will be discussed. To evaluate the performance of the game and moreover possible benefits in the process of learning, the approach and research methodology of the conducted field

test is laid out.

The fifth chapter occupies itself with the implementation of the prototype. At first the design and the story of the game will be explained followed by a detailed description of the layout and the various sections of the game and the provided exercise types. Afterwards the used technology to develop a cross-platform app will be explained, supported by various code listings.

The second to last section describes the results and findings of the conducted a field test and points out positive and negative aspects of the developed prototype. The conclusion summarizes the results and provides a recommendation if Digital Game-Based Learning should be used in the future to support children.

2 Game-Based Learning [1]

2.1 State Of The Art

The term Game-Based Learning has its roots in the Anglo-American region (Le, Weber, and Martin Ebner, 2013). In the last decade, the number of published essays, papers and articles about the effectiveness of DGBL has increased. James Paul Gee's "What Video Games Have to Teach Us about Learning and Literacy" (Gee, 2003), Marc Prensky's "Digital Game-Based Learning" (Prensky, 2003) and Richard Van Eck's "Digital game-based learning: It's not just the digital natives who are restless" (Van Eck, 2006) are only some publications to be mentioned. Those authors already started to highlight the importance and power of DGBL in education years ago.

While the interest in games as learning tools was not of much interest at the beginning, the public attention eventually increased because of three main factors (Van Eck, 2006). The conducted research of DBGL advocates in the past years is the first factor, which contributed to more attention. Secondly, today's generation changed in its behaviour. These so-called "Digital Natives" demand information in new ways (Van Eck, 2006). The Horizon Report in 2012 supports this factor in one of its identified key trends for the future: "People expect to be able to work, learn, and study whenever and wherever they want to" (Johnson et al., 2013). The third factor is the gaming industry, which will generate revenues of nearly $108.9 billions in 2017, verifying the popularity of games in today's society.

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On closer examination, one could come to the conclusion that games are justifiable learning tools. Numerous papers and essays talk about the positive effects of games, but take no spin on the disadvantages. Richard Van Eck (Van Eck, 2006) is a proponent of games as learning tools, however, he also warns about categorising all games as effective. In his opinion, researchers must not only clarify why DGBL is effective and valuable, but also provide instruction on how and in which context usage must take place, in order to support the learning process in the best way possible.

Furthermore, Marc Prensky described the problem of "academizing games" or "sucking the fun out". Games are complex: They combine art, design, and creativity. When researchers started to create games, these key properties often lacked attention, resulting in products, which did not increase the learning efficiency. Nevertheless, games still had an impact on the effectiveness of learning. Nowadays, the problem of creating games with educational value, which are still fun to play, is sorted out (Van Eck, 2006).

2.2 Games in Education

The role of games in education is becoming more important. The mobile gaming sector is more attractive than ever before. Almost every child aged 15 in Central Europe owns a smartphone or mobile device (Hannak, Pilz, and Martin Ebner, 2012). In Austria already each child aged 10 years owns his/her own device (Grimus and Martin Ebner, 2014). Over the past years, such devices continued to grow in power, which is also a benefit for learning purposes. Furthermore, teachers and students think of interactivity as something very important in education (Kozma, 1991) (Hannak, Pilz, and Martin Ebner, 2012).

The following chapters will explain, why games matter in education. First of all, the process of learning will be described, continued by the area of Digital Game-Based Learning. Moreover, the implementation and effectiveness of DGBL will be pointed out by presenting some successful real life examples.

2.2.1 The Process of Learning

Learning can be described as an active cognitive process, in which knowledge and understanding is created by the learners themselves (Motschnig-Pitrik and Andreas Holzinger, 2002) (Martin Ebner and Andreas Holzinger, 2002). Also, researchers claim that the process of learning is strongly connected with bringing knowledge in practice. Back in 1916, John Dewey (J. Dewey and E. Dewey, 1915) stated the famous quote "Learning By Doing". Students need to be encouraged to gain sustainable knowledge. Further, (Vygotsky, 1980) summarized the connection between interaction and learning with only three sentences:

- The current knowledge base of learners influences their future success.
- Interaction enables knowledge creation.
- Interactive problem solving is the goal of learning.

Researchers recognized that students do not only learn best from generalisations or abstractions (DiSessa, 2001). They rather also learn via principles derived from their personal experiences. The next time they are confronted with a problem, such knowledge can be utilized and generalization can take place. This leads to the conclusion that students should pursue learning by doing than by memorising numerous textbooks (Gee, 2013).

The Traditional Way

For decades, the transfer of knowledge in education has been realised by the use of books and students willing to put in countless hours to memorize content. Even nowadays, children in schools, as well as students at universities, are used to gain knowledge from textbooks, at least in Austria (Walther Nagler, Martin Ebner, and Martin Schön, 2016). The most part school systems hold on to this way of education. Textbooks still account for at least 70% of the classroom instruction and provide guidance for teachers in the fulfilment of their curriculum (Tyson and Woodward, 1989).

However, scientists maintain the position that textbooks are one of the

worst educational inventions and simply do not work as good as people think (Graesser et al., 2004). Such books are mostly filled with generalizations and abstractions, which are not ideal for learning purposes, as research recognised (DiSessa, 2001). The ability to receive information with context is a key part of the studying process (Barsalou, 1999). Programmers will not learn to write code by reading a book. James Paul Gee from Arizona University is convinced that studying takes place while experiences are made (Gee, 2013). With the help of teachers, such experiences can lead to the creation of mental models and deep knowledge.

Abstractions and principles in textbooks are written by people with experience and the ability to transfer their knowledge into words (Gee, 2013). How are primary school children supposed to learn and understand concepts from books without any experience? David W. Shaffer from University of Wisconsin-Madison supports Gee's view on textbooks. Furthermore, he considers "facts" as the tools required for the process of problem solving, which then results in better preservation of knowledge (Shaffer, 2006).

Especially primary school children are confronted with difficulties when it comes to gaining valuable experiences. Much effort and commitment must be put in by teachers to design them in an appropriate way, while making sure that important learning concepts receive the attention they deserve (Gee, 2013). From a research perspective, the call for a new educational technology such as DGBL is obvious.

The Future of Learning

Many questions arise when thinking of the traditional way of learning, compared to the presented results of researchers and scientists. According to Prensky (Prensky, 2003), motivation is an indispensable element of learning. In his opinion, the current school system is boring and dry, without any fun. Furthermore he claims that teachers and educators are not as effective as they could be. In the past years, the number of debates on new educational concepts has increased. According to Sandford and Williamson (Sandford and Williamson, 2005) games could have various advantages: "Computer games are designed "to be learned" and therefore provide models of good

learning practices, and that by playing games young people are developing practical competencies and social practices that are equipping them for 21st century workplaces, communication, and social lives". Games are part of a multi-billion dollar industry, which is more successful than ever. If one considers the countless hours of students playing video games, or kids playing games on their smartphone, a huge potential in learning could be seized if just a fraction would be spend on educational games. Nowadays, researchers look at games as educational tools with eager anticipation.
Furthermore, students require new ways of learning. Instead of being consumers, they actively want to be producers and take control of their learning (Klamma, Cao, and Spaniol, 2007). The explicit usage of technologies that serves their needs and preferences underpins this change (Sandford and Williamson, 2005). Especially the introduction of the Web 2.0 created new ways of knowledge creation. According to a study (Lenhart and Madden, 2005), 57% of online teens are actively involved in the creation of content, such as blogs, videos, work for school or personal webpages. Self-authored content is among the top activities and very often, existing creations on the internet are combined to create new ones.
These examples show that today's kids and students have different demands, which need to be addressed. Based on various possibilities introduced by the Web 2.0, this thesis will discuss Game-Based Learning as a new promising concept in education.

2.3 Digital Game-Based Learning

Game-Based Learning (GBL) is a concept in which selected problem scenarios are embedded into a play framework (Martin Ebner and Andreas Holzinger, 2007). GBL is similar to Problem-Based Learning (PBL), which assumes that the process of solving everyday problems generates knowledge and supports learning in an efficient way (Hung, Jonassen, Liu, et al., 2008). Especially in the field of medicine, this approach has shown various advantages (Barrows, Tamblyn, et al., 1980). Furthermore, proponents of PBL argue that learning fades out after the basic education in school. A famous advocate of PBL, Karl Popper (Popper, 1995), covers an even more supportive view. He says that "Alles leben ist Problemlösen [life is all about

problem solving].", which means that we need to solve problems throughout our whole life, therefore the chances of everyday learning are omnipresent.

As mentioned before, today's school children demand different types of education. In a world where children grow up with smartphones, tablets and the Web 2.0, textbooks are outdated. Prensky (Prensky, 2003) estimated, that kids spend up to 10,000 hours playing computer games before they reach the age of 21. In addition, a survey among 2000 children revelaled, that children spend one hour per day on playing video games (Rideout, Foehr, and Roberts, 2010). While the gaming industry was able to grow with the help of this addictive behavior, researchers recognized the possible power of games in education. The biggest German research study on media usage among the youth in 2017, called JIM (Jugend, Information, (Multi-) Media) ((mpfs), 2017), pointed out that 97% of young people are in possession of a smartphone. According to JIM ((mpfs), 2017), the smartphone has already become indispensable as it serves as a multimedia tool. When it comes to media activities, three out of five teenagers play video games multiple times a week, using the smartphone as their favourite device. The JIM study further recognized, that only the computer and the whiteboard have made their way into the school system while the smartphone and tablet are not widely adopted yet. These findings underpin the importance of digital games as a learning tool.

2.3.1 Cognitive Benefits of Games

Various analysis over the past years have shown that games effectively reduce the number of educational instructions and support the learning progress, independent of the age or the discipline (Szczurek, 1983). Despite the fact that these reviews have been about games in general, Richard Van Eck (Van Eck, 2006) has no doubt that digital games as a medium will cause a negative influence. In his paper (Van Eck, 2006) about DGBL, Eck argues that "Games embody well-established principles and models of learning". An important aspect to mention is the principle of "situated cognition". The procedure of learning with meaningful context has shown increased

effectiveness in comparison to the traditional way of formal instruction. On the opposite, games provide meaningful context, as players are required to take actions. When young people play video games, they learn throughout the game as actions are based on the context and environment of the game (Van Eck, 2006). Despite that, other cognitive benefits can be explored by games in education. The theories of Jean Piaget (Piaget, 1976) about the concepts of accommodation and assimilation underpin the advantages of games.

Assimilation is about the categorization of new information within our brain. Thereby humans try to connect and classify new input with existing knowledge. For example, a young child sees a black cat for the first time. At the beginning, the child thinks that the fur of a cat is only black. After some time, the child discovers different types of cats with different colored fur. This information is then connected with the existing knowledge about cats. Accommodation is about the categorization of new information, which does not fit into existing knowledge. A good example for accommodation are animals. A lion and a cheetah may be the same for a young child. Then the parents explain that a lion is bigger and typically has a mane. The child then needs to accommodate this new information.
Both processes lead to another one, called "cognitive disequilibrium". Eck (Van Eck, 2006) describes this process with a very simple example. If the engine of a car does not turn on, and this already happened earlier as a result of a damaged battery, then a person assimilates this problem and changes the battery. With accommodation, a damaged battery may or may not be the cause, so new types of failures are taken into consideration by the person.

Games reflect assimilation, accommodation and cognitive disequilibrium. These processes determine whether a game is successful or not. When children play games, they make decisions and get feedback from the game. A challenging game always requires a player to rethink and change the inputs in order to be successful. Easy games are not attractive and therefore do not deliver the desired learning effects.

2.3.2 Learning and Design in Games

Successful games are often difficult to master. The game Candy Crush Saga which was developed by a company called King, in collaboration with Facebook, quickly gained more than 40 million users per month[5], even though the game itself is very challenging. Another success story is the game Farmville. In Farmville, the players have to build and manage their own farm. It is claimed to be the fastest growing Facebook game ever. The game was introduced in July 2009 and already counted over 33 million users in September, before it was released for iOS and Android as well.
Paul Gee (Gee, 2005) noticed that people generally deal differently with difficulties. According to Gee, people are either forced to manage challenging tasks, like in school, or they find ways to avoid them. It is interesting that the game industry is an exception and this phenomenon does not apply to it. But what makes games successful? What causes the gaming industry to grow year by year?
For Gee, it is all about design. Good design motivates players to play countless hours, even though the game confronts them with various challenges on their way. Players nearly get lost in time as they are entertained by such games. This chapter will explain how the design of a game directly affects the process of learning.

"The designers of many good games have hit on profoundly good methods of getting people to learn and to enjoy learning" (Gee, 2005). Furthermore, learning principles, which are embodied in successful games, can be compared to principles found in cognitive research. When it comes to the design of a game, good gaming designers are confronted with various challenges. The reasons for these challenges are diverse.
First of all, good games always provide information "on demand" and "just in time" (Gee, 2003). According to the research of multiple authors (Barsalou, 1999; Brown, Collins, and Duguid, 1989; Glenberg and Robertson, 1999), people experience problems when they receive information without context or at an inopportune moment. In this case, neither the information is understood and remembered for a long time, nor can this information be used for upcoming problem cases. Thoughtful game designers oppose

[5] *Candy Crush Saga SuccessStory* 2017.

this threat by introducing tutorial activities or levels, which enable to learn basic principles of a game. Moreover, basic abstractions and generalizations take place. In his book about "Incremental Learning" (Elman, 1991), Jeffrey Elman argues that the early confrontation of players with complex problems may lead to plausible solutions at first. However, afterwards the players are not able to manage the complex problems presented. Good game designers carefully think through the order, in which problems are revealed to the player. In fact, everyone who ever played video games was indirectly confronted with a proper problem order. Many games start off with simple enemies, players learn to use weapons or tools and reach the next level. As the game continues, enemies become stronger and players have to use multiple tools in order to beat the opponent. In the end, an end boss often needs to be conquered. Bereiter and Scardamalia (Scardamalia and Bereiter, 1993) call this the "cycle of expertise". Throughout a game, players will create expertise by experience.

As described in earlier sections, motivation is the key to learning. If people, especially children, loose motivation in what they are about to learn and experience, they will not remember much information or build knowledge. Andrea DiSessa (DiSessa, 2001) pointed out, that it was very difficult for science to define motivation at all. One definition describes motivation as a desire to learn new areas and additionally provide more willpower pursuing it than normally. According to Gee, motivation is the most important factor of all. In his opinion, children only study when they are motivated. If their motivation is gone, learning cannot take place. In fact, one depends on the other. As mentioned earlier, researchers see the textbook as the worst invention ever. How are kids supposed to be motivated by textbooks? This kind of medium provides no experience, one of the most important factors.

Games seem to have various advantages over traditional learning methods. Another important aspect of video games is the chance to act at a certain distance, similar to driving an electric car with a remote control. According to Clark (Clark, 2003), such actions at distance cause human minds to feel as if they expanded unknown space. Furthermore, the ability to control and act as a certain character is very motivational for children. This opportunity helps to improve deep learning, something other mediums like textbooks cannot. However, Gee (Gee, 2003) highlighted the importance of recreation.

Children are able to recreate themselves and dive into a new world full of opportunities. In the meantime, improvements in the creation of knowledge can be realized.

2.3.3 Creation of Good Games

In fact, a lot of research about the advantages of DGBL has been conducted throughout the past years. Mostly, these articles, books and papers are about the power of DGBL and the new possibilities connected to it. Furthermore, the gaming industry has shown continuous growth, becoming a multi-billion dollar industry. Therefore an analysis on the quality of the games must be undertaken. First, it is important to mention that not every game improves learning. According to Eck(Van Eck, 2006), several questions have to be answered.

- Why is DGBL effective?
- How can games be engaging?
- Provide information on how, when and under what constraints DGBL should be used.

In addition, Eck offers some criticism on the conducted research. Proponents mainly focused on the possible effectiveness of games. But what makes games effective? Why is a particular game helping children to learn? How can DGBL be implemented? On closer examination, it can be stated that there is a lack of qualitative and evaluated answers, even though some research has been conducted on how to use games in learning (Rieber, 1996; Van Eck and Dempsey, 2002).

Learning Systems

"Good learning is a system – a complex system – in which minds, bodies, times, places, languages, and tools interact in complex ways"(Gee, 2013). According to Gee, games can definitely improve studying in powerful ways (Gee, 2003). Furthermore, he claims that not video games, but a good learning system is the decisive factor. As mentioned above, textbooks do not offer good learning systems, as they try to fit for all children and students.

In various studies, Gee worked out a list of properties that good learning systems embody (Gee, 2013).

- In addition to information and facts, they concentrate on well-ordered problems.
- They support the creation of important non-cognitive skills, for example taking on challenges, accepting failure and being consistent in putting in effort and passion to achieve goals.
- Good learning systems provide the necessary tools to solve the introduced problems.
- They provide well-defined goals and motivate to think about the game.
- Very importantly, such systems make it possible to fail. In this way, players can experience, take risks and try out different ways of playing.
- Experience is the most important property. They do not focus on information or facts to build the needed competence, but on learning and exploring to give meaning to words.
- They provide a lot of feedback for the players, for example tutorial levels or hints in games.
- They make it possible to create new designs, for example a skating game where a player can build his/her own skate park.
- Every level should challenge the player in a new way, also, it should be possible to master these challenges with the build knowledge from the levels before. This process is called "the cycle of expertise" (Scardamalia and Bereiter, 1993).
- They focus on what players can achieve, not when or where they started.
- Good learning systems make sure that players use collaborations in order to solve problems together rather than alone.

These are just some properties of good learning systems. Video games are not only a medium to be used, teachers can design such systems as well, called "Teaching as Designing (TAD)" (Gee, 2013). In this process, teachers design experiences for children, which embody the principles of good learning systems. On the one hand, a teacher could be a designer of valuable experiences. On the other hand, a designer may be a good teacher. The combination of both results in games that really help improve the process of learning for children. However, games have shown their

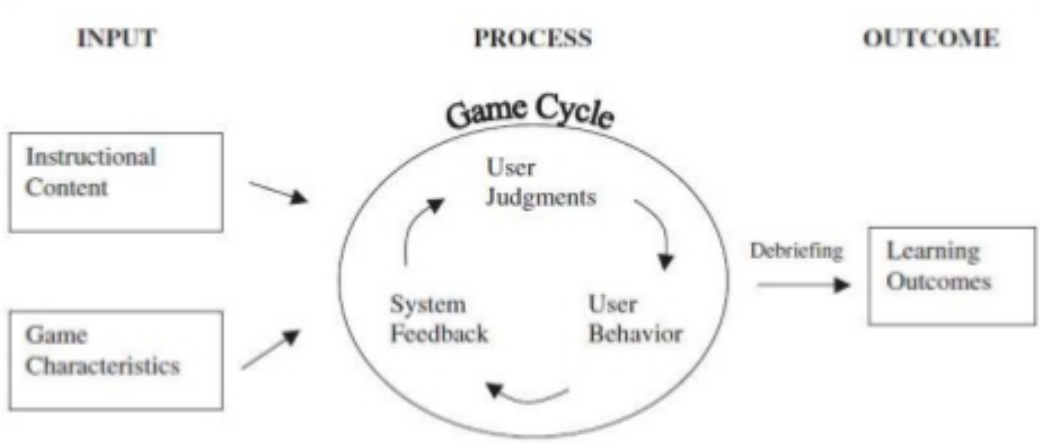

Figure 2.1: Input-Process-Output Game Model (by Garris and Driskell, 2002)

effectiveness and potential, but the crucial factor behind is the learning system.

Learning Potentials of Game-Based Learning

The introduction of Digital Game-Based Learning, for the purpose of enabling positive study effects for school children, is expected to bring a lot of potential with it. Games cut out the boring aspects of learning with a textbook. Games cause children to unwind and loose the feeling of being forced to study. In addition, games promote an intensive personal debate about the game, as players need to think through various challenges. As argued before, problem cases are introduced and arranged by difficulty, so the players are not overtaxed. The Input-Process-Output Game Model by Garris and Driskell explains how games work. First, there are two inputs to the game. The first one is the learning content that should be transmitted to the players, the second one is the game properties. It is important to mention that the properties of games should correlate with the ones of good learning systems, as explained by Gee (Gee, 2013).

While a child plays a game, several iterative phases can be observed. In the

middle of these phases the game cycle takes place. Around this event, the player constantly receives feedback from the game. Such feedback not only helps the players to improve and rethink their actions. Also, it indirectly encourages them to learn in a deep way. In addition to the system's feedback, players are rated and evaluated by their actions. Good games keep track of a player's progress and motivate one by awarding achievements or collectables. The last event in the cycle is a player's behavior. The actions and decisions of the player determine the feedback. If players get stuck in certain sections, good games make sure to deliver the necessary information to them. All those iterative phases throughout the playing process lead to the collection of data. Such data can be used for Learning Analytics, which allows measuring the learning results. This analysis is then used to determine the positive and negative effects of using the game for educational purposes.

Digital Game-Based Learning promotes several types of learning, as indicated by Meier and Seufert (Meier and Seufert, 2003):

- Active Learning - Through playing the game
- Constructive Learning - Try and fail without consequences and create personal experiences with context
- Self-driven Learning - Actions are freely chosen by the player
- Social Learning - Use multiplayer games and cooperation to solve problems together
- Emotional Learning - Evoke personal feelings of players through deep participation with the content of the game
- Situated Learning - Play different characters in games and solve different types of problems based on the role of the character

One can clearly see the potential of game-based learning from the types listed above. According to Helm and Theis (Helm and Theis, 2009), game-based learning is strongly connected with intrinsic motivation. Furthermore, it helps to improve strategic thinking and the ability to master problem cases within a given context. Another advantage is the chance to gain more cognitive skills. Players may not only be forced to deal with complex situations, they rather start making decisions and think through possible alternatives (Le and Weber, 2011).

On closer examination, there are many more potential advantages of game-based learning, which can be realized by players. However, it is important to indicate the benefits of this approach for education, which is why it should definitely be considered a serious option.

2.3.4 Implementation of Digital Game-Based Learning in Education

A lot of research has been conducted on DGBL and proponents have highlighted the effectiveness and power behind it. In addition to that, there is guidance on how to build and design a good learning system as well. In order to help children to study in a more effective way, such games have to be implemented. Generally, three approaches have been identified to support the process of learning (Van Eck, 2006)

- Games which are build by students from scratch
- Games which are build by developers or educators/teachers to teach children
- COTS - Commercial Off-The-Shelf Games

The first approach gives children the ability to be game designers and build their own game. Through the process of building the game, children effectively learn the content and principles behind it. By this approach, problems are solved and skills are sharpened and improved. However, generally a commercial game takes at least one year to develop. This requires many people, like designers, developers and artists to work together. It is very likely that such a time consuming process is not feasible for schools. Yet, such professional games are not necessarily required for educational purposes. Nevertheless, it still takes a lot of time and teachers need to be able to make use of it. In certain subjects or areas, it may be harder than in others. Still a lot of educators teach in a traditional way, making it unlikely that this approach will be conducted frequently.

The second approach is often denoted as the ”Holy Grail” approach (Van Eck, 2006). Compared to the first approach, this one actually requires the development of high quality games, which provide entertainment and help

to improve the process of learning. In order to achieve that, a lot of resources are required to reach the same quality as COTS games. COTS games are well-designed, they arrange and present problems in a smart order and improve studying and problem solving in a lasting way. There are already several good games that have been developed by companies (e.g. Toca Doctor from Toca Boca[9]), but many others struggle to deliver educational benefit at all. Moreover, companies are very careful with decisions in the area of edutainment. Edutainment is the combination of education and entertainment. While Eck (Van Eck, 2006) describes this approach as the future of DGBL, companies have a hard time making profit in this field of games. The effort in the creation of such games will increase as soon as parents, schools and teachers accept DGBL as much as they accept textbooks.

The last approach is about Commercial Off-The-Shelf Games and how these can be embedded into the process of learning. Against the two approaches described before, this approach takes existing commercial games and tries to use them in school for educational purposes. While this way of procedure is the most expensive one, Eck considers it as the most effective one for short- and long-term usage. The two main advantages for short-term usage are the availability and efficacy. In the long-term, it could help science to reach the required attention of game development companies, in order to start creating more serious and professional games for education. Another advantage is the separation of teachers and game designers. With this approach, game designers can focus on the creation of games, while teachers are able to select the parts of the games they consider as useful for the improvement of their student's learning skills.
Research has shown that this approach definitely has a future in terms of practicability, feasibility and effectiveness (McFarlane, Sparrowhawk, and Heald, 2002). In addition to the promising opportunities of this procedure, nearly 60% of all teachers in the United Kingdom are in favour of computer games in school (Futurelab, 2006). Also, a large game developing company named Entertainment Arts (EA) started a collaboration with the National Endowment for Science, Technology, and the Arts (NESTA) to conduct a research about COTS games in schools.
Despite all the advantages of COTS games, there are some disadvantages

[9] `https://tocaboca.com`, last accessed December 27, 2017

as well. As such games are not designed for educational purposes, an analysis has to be undertaken. The difficulty lies in the ability to examine the available content, which may be inappropriate, as well as the strengths and weaknesses of the game (McFarlane, Sparrowhawk, Heald, et al., 2002).

To replenish this chapter, it is crucial to mention that DGBL is not simple and easy to pursue. It is a complex process, which needs a lot of attention. Not all games have the capability to support the learning process of children. Different types of game taxonomies produce different learning results. According to research (Van Eck, 2006), card games are well suited for studying concepts and to memorise patterns. Jeopardy-style games are best suited for studying facts and information. Arcade games help students to improve the speed of their responses and processing of information, while adventure games best promote to improve problem-solving skills. To achieve the best possible results, game taxonomies need to be selected carefully in oder to achieve the desired learning goals.

2.3.5 DGBL Examples

One of the most famous experiments in DGBL has been conducted in 1985 for the National Council of Teachers of Mathematics with the goal to teach students mathematics (Bright, Harvey, and Wheeler, 1985). In total, eleven different games have been developed for 1,637 participants, targeting different grade levels. Researchers were especially interested in how these games could help teaching mathematics, with respect to different learning levels of students. In addition, the authors categorized the eleven games into three separate instruction categories. The first was pre-instructional, the second co-instructional and the third post-instructional. This timely categorization relates to the point of usage according to the curriculum.
The results of the study pointed out that the games had caused a positive effect in learning. Furthermore, the authors recognized different results across the different learning levels, as well as an influence on the pre-, co- or post-instructional approach. In conclusion, the study pointed out that learning games might produce positive learning effects for students.

However, the implementation and design of the games are crucial.

At Graz University of Technology, an interactive game was developed to support secondary school students in learning geography (Martin Ebner, Böckle, and Martin Schön, 2011). One of the goals of the study was to observe, whether a challenging online game is able to encourage students to learn. Furthermore, the results of those students were compared to another group, which did not use the learning game. The method used to evaluate the impact were questionnaires, which were conducted before and afterwards.
After the evaluation of the final questionnaire, the group of students using the interactive online game performed significantly better than the control group. Additionally, the students found it more motivating than the traditional way and enjoyed learning though a game.

Also, a game called "Smartass" has been developed at Graz University of Technology, with the intend to integrate e-learning on smartphones. (Hannak, Pilz, and Martin Ebner, 2012). At the time of the development, trivia games delighted people and were more popular than ever. Therefore, the game was implemented as such, taking advantage of the people's initial motivation when it comes to quiz games, shows or pub quizzes (Andreas Holzinger, Pichler, and Maurer, 2006). In addition to that, trivia games have found themselves highly attractive, as they cause unintentional learning (Holzinger, 1999). In addition to the statements, which have to be answered by the players, jokers were introduced as a fun element. Jokers made it possible to mirror a statement, for example, making it difficult to read and answer for others. Statistics were also visible to players, so they could keep track of their achievements and results. The authors also introduced a GPS-based mode, which could be used to link a set of questions with coordinates.
The game was tested among 20 users, aged from 18 to 26. Furthermore, the players answered 150 statements across various categories. The difficulty of the questions varied from easy to challenging. To evaluate the result, four

explicit research questions were defined by the authors (Hannak, Pilz, and Martin Ebner, 2012).

1. "Does playing the game results in a better user performance in the long run?"
2. "Does implemented Jokers make the game funnier?"
3. "Are statistics as well as scores essential for the game?"
4. "Are location-based questions an innovative and challenging part of the game?"

The first research question could be confirmed. It was possible to observe coherence between the played games and the amount of correct decisions. In fact, playing the game for 15 times caused the number of correct answers to increase more than 100%.
Also, the added jokers performed as the authors expected. Nearly three quarter of the people who participated showed an increase in motivation to play a rematch.
Statistics were not as successful as the jokers. Half of the players only rated it at little motivating. However, the authors pointed out that they did not show real time results, which might be a possible reason for this evaluation.
The GPS mode received a lot of positive feedback. Players hold this feature in high regard and added that they would use it again in the future.
In conclusion, the authors confirmed their hypothesis and proved that games can positively influence learning. As players play the game more often, an increase in correct results can be seen. According to the evaluation, the result is incidental learning.

2.3.6 Gamification

The term "Gamification" has gained a lot of attraction throughout the last years. A literature review of empirical studies back in 2014 revealed a significant increase in publications (Hamari, Koivisto, and Sarsa, 2014). Despite the hype around this term, researchers have struggled to come up with a clear definition. In addition, Gamification is surrounded by various

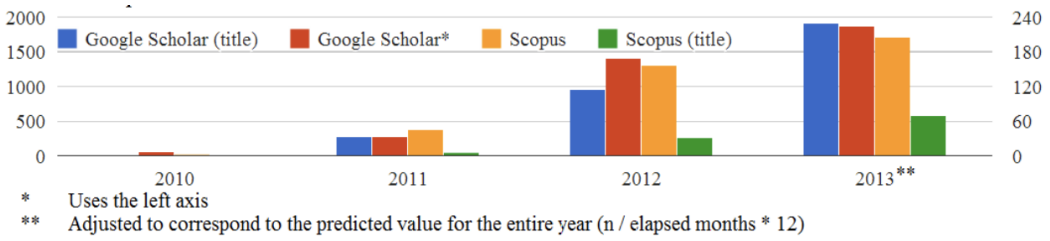

Figure 2.2: Search results of the term "Gamification" (Hamari, Koivisto, and Sarsa, 2014).

myths. People very often associate it with games and badges, coins or achievements. However, a closer look on literature allows clearing out the myths. This section will briefly discuss the history of Gamification, followed by an explanation of the advantages. In the end, examples on how to use Gamification will be provided.

Towards a Definition

Gamification has its roots in the digital media industry. The first references to it go back to 2008 (Paharia, 2010), although it did not receive a lot of attention in the beginning. By time, more attention was brought to it, before seeing a widespread interest from 2010 on (Deterding, Dixon, et al., 2011). A review on existing empirical studies in 2014 pointed out, that Gamification definitely started to grow in interest among researchers and scientists. Figure 2.2 illustrates a snapshot of the number of publications on this specific topic. With the increasing interest, a lot of questions arose as well.

What is Gamification? One cannot find a predominant definition. Therefore, several are quoted:

1. "Simply, gamification is an emergent approach to instruction. It facilitates learning and encourages motivation using game elements, mechanics and game-based thinking (Kapp, 2012)."
2. "...a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes (Hamari, Koivisto, and Sarsa, 2014)."

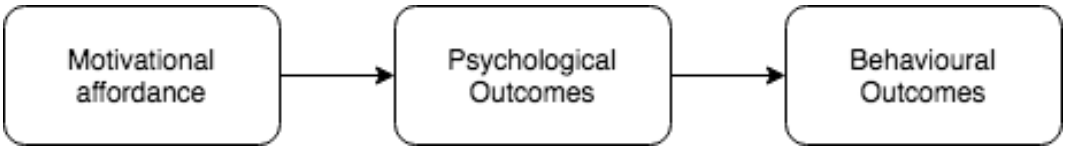

Figure 2.3: The three main phases of Gamification by Hamari et al. (Hamari, Koivisto, and Sarsa, 2014).

3. ""Gamification" is an informal umbrella term for the use of video game elements in non-gaming systems to improve user experience (UX) and user engagement (Deterding, Sicart, et al., 2011)."
4. ""gamification" as the use of game design elements in non-game contexts (Deterding, Dixon, et al., 2011)."
5. "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation (Huotari and Hamari, 2012)."

Considering the parallels of the listed definitions, one can say that Gamification has something to do with enhancing motivation, usage of game elements and user experience. Moreover, it can be applied to games or in non-game contexts as well, for example motivating employees in a company. Primarily, two concepts have been dominant in the industry. The first concept targets the adoption of games in our daily lives as well as the institutionalization, taking advantage of all the ubiquitous properties of games (Chatfield, 2011; Chatfield, 2011; Schell, 2010). The second approach is a little different. Games are about entertainment and players forget about time and space while playing great games. The elements of a game, which cause these properties, are highly valuable for non-game contexts as well. Therefore the second industrial approach is the use of such game elements within other contexts as well (Deterding, Dixon, et al., 2011).

According to Hamari et al. (Hamari, Koivisto, and Sarsa, 2014), the process of Gamification can be visualised by three main elements, as shown in figure 3. In the beginning, motivational affordances like points, badges, leader-boards or collectables, are integrated. Furthermore, these result in psychological and behavioural outcomes. As mentioned earlier, a literature review on Gamification in 2014 has shown that it can lead to several positive effects. The psychological measures undertaken have been primarily the

motivation and enjoyment. In the context of educational use, an increased engagement in fulfilling learning tasks could be observed. Yet, some disadvantages were recognised as well. In some areas however, for instance utilitarian service setting, not such a strong improvement can bee seen. In addition to that, educational appliance also showed some negative affects in terms of competition among players.

Myths about Gamification

Games and Gamification are often compared or even considered the same. Thus, it is necessary to point out that such a connection does not exist. Of course both terms are related to each other, but they are not the same. As time went by, a lot of myths about Gamification have come into the open. In order determine the real purpose, some popular myths according to Kapp are listed below (Kapp, 2012). In further consequence, they will be explained in order to resolve the confusion around this topic.

1. There is no difference between Gamification and Games
2. Older people are not attracted by Gamification and therefore turn away
3. Gamification provides no scientific background and is just a hype
4. Badges, Rewards and Collectables - This is Gamification

The first myth looks upon game and Gamification as the same. Typically a game has a certain flow. Players engage with the game, master challenges and learn in many different ways. Most of the time games provide their players with a clear goal, for example beating the final enemy by combining all their gained knowledge. To refute this myth, an analysis on game design elements as well as strategies must be undertaken.

According to Schell (Schell, 2014), a game consists of four main elements, ranked by visibility to the player, as shown in figure 4. Aesthetics are the most visible game element for players. Examples are game sounds, the interface, animations or other elements, which create a good atmosphere for the player. The next visible element for players is the game mechanics,

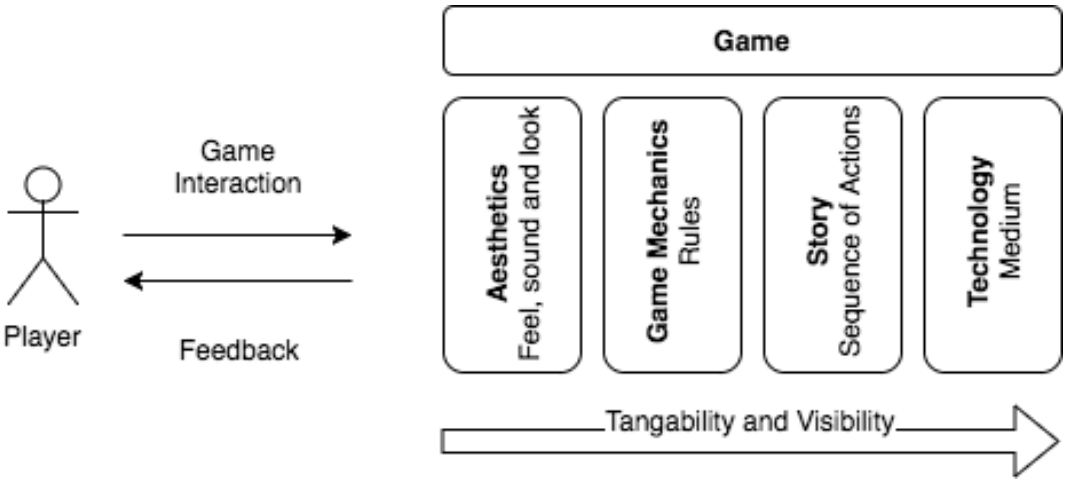

Figure 2.4: According to Schell (Schell, 2014), players interact with a game and receive feedback from the system. A game consists of four main game elements, with some more visible and some less visible to the player.

which define the procedures and rules on how to play the game. Followed by the mechanics, the game story helps players to understand the intention of the game, for example building up an empire or a farm. The technology of a game is nearly invisible for the player and basically embeds the other game elements. When a game is designed to be effective, Schell points out that all four elements must be aligned.
Gamification makes use of different game design elements (Deterding, Dixon, et al., 2011). Pirker (Pirker and Gütl, 2015) states that frameworks for Gamification concentrate on fun and motivating game elements, but ignore concepts that are based on the story game element of Schell. While there are different approaches on how to realize a Gamification strategy, the timely distribution seems to be more straightforward. Gamification does not take place at a certain period, it is rather equally split over the whole game to constantly motivate and engage players. Often, games use reminders to get in touch with their players.

Secondly, people often fear the usage of Gamification, as they believe that older people are not attracted by it. This myth belongs to the appliance

of Gamification in non-game contexts, like companies trying to improve collaboration among employees or refresh knowledge in a playful way. The report "Gamers Over 50: You're Never Too Old to Play" by the Entertainment Software Association et al. (Association et al., 2012) supports the refutation of this myth. According to it, nearly 50% of persons aged 50 or older confess that they play video games. Furthermore, nearly 50% stated that they consume games on a daily basis. Thus, one can say games and gamification is attractive across all age groups.

Another popular myth claims that there is no science behind gamification. According to Kapp, Gamification platforms make use of retrieval practice and spaced retrieval, two different learning methods. Retrieval practice challenges people by forcing them to recall information they have received earlier, without reading or consuming this information again. Spaced retrieval takes a slightly different approach by distributing information over time in small chunks. Kapp (Kapp, 2012) further argues that if learners consume small chunks of information on a weekly basis combined with game elements, Gamification can lead to long-term retention.

The last myth finds itself surrounded by badges, coins, achievements or other collectables as the main elements of Gamification. There is a belief that such elements automatically guarantee a successful Gamification strategy. However, people are not interested in coins or badges (Kapp, 2012). Good Gamification provides a story and maintains a strong interactivity with the players. It motivates players to overcome difficulties and compare themselves with others.

Gamification in educational Contexts

While teachers strive to come up with new engaging ways of education, school is mostly considered as boring among children. A lack of motivation and engagement leads to ineffective learning and therefore implicitly calls for new educational methods (Lee and Hammer, 2011). Learning by design

and Digital Game-Based Learning show great potential to overcome the current challenges. Games do not only enable various types of learning, they also cause players to loose themselves in thought and therefore increase motivation and engagement. Gamification has experienced a lot of attention in the past years, mostly in non-game contexts. As this thesis discusses the development of a mobile app for primary school children, a look on its use in educational contexts must be pursued.

Companies around the world cover themselves with success through Gamification. Popular examples are Foursquare or Nike, which offer various loyalty programs. Stack Overflow, a highly admired forum among developers, rewards users for helpful answers. Developers can vote answers up or down, allowing users to build a reputation within the community. Gartner's 2013 Hype Cycle for Emerging Technologies (Rivera and Meulen, 2013) came to the conclusion that it will still take up to ten years until Gamifications reaches a Productivity Plateau. However, most publications talk about the use in non-educational contexts. A research conducted by Dicheva et al. (Dicheva et al., 2015) explicitly focused on educational purposes. The authors examined the following questions:

1. What educational contexts has Gamification been applied to?
2. What game elements have been used in gamifying educational systems?

The study searched seven scientific databases and filtered the results by the keywords "gamification", "gamify" and "gameful". In succession, publications, which were not related to education, have been filtered out. Despite that, the authors focused on reviewed publications as well as not considering early literature on the topic itself. Afterwards the selected literature has been reviewed. As a result, a separation of game elements into Gamification design principles and game mechanics has been made.

The obtained results about Gamification design principles showed that mostly visual status, social engagement, freedom of choice, the possibility to fail without real consequences, as well as rapid feedback are used in such

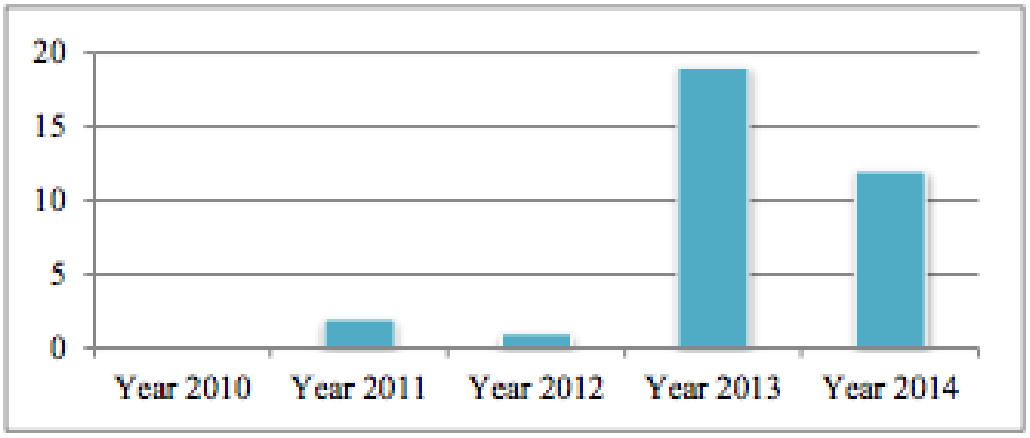

Figure 2.5: Work distribution about the use of gamification in education from 2010 to 2014 according to Dicheva et al.(Dicheva et al., 2015).

games. Yet, principles like personalization or unlocking content are of less interest.
Bages, Points and Leader Boards are found to be the most important game mechanics, while virtual goods and avatars did not receive as much attention.

The conclusion of the authors regarding the use of Gamification in educational contexts is manifold. On the one hand, the exposed results on literature led to the fact that publications mostly elaborate on game mechanics and dynamics. On the other hand, there are some parallels to DGB, as criticism is offered against the literature, which only refers to the possible utilization and the related advantages in educational context, rather than laying out real results on positive learning effects. While all the authors agreed on the positive aspects of Gamification when implemented correctly, they also pointed out that no real conclusion could be drawn from the existing literature due to inappropriate evaluations. All in all, Gamification can work and improve the learning environment in various ways. The utilization, however, needs to be carefully investigated as the final conclusion of the authors confirms:
”While the concept of gamification may look simple, the analyzed work demonstrates that gamifying learning effectively is not”(Dicheva et al.,

2015).

2.3.7 Conclusion

The game industry as well as educational institutions has developed various games in the last decade. Such games may have the potential to revolutionize the way students and children learn. As explained in the previous chapters, there are many crucial factors to consider. The most important ones derived from this thesis are therefore listed:

1. Not all games are suited for learning
2. The learning system behind a game is indispensable
3. Allow children to experience, think, fail and succeed
4. Provide context and feedback to players based on actions and decisions
5. Be aware of pre-, co- and post-instructional learning
6. Use Gamification to motivate players and keep it fun to play the game

If one eye is kept on these properties, it seems that games can positively affect children in educational contexts. Yet, a frequent criticism is offered on publications, which do not provide proper evaluations or guides on how to implement Digital Game-Based Learning. Far too many papers merely talk about the positive effects that could be provided, rather than laying out a clear strategy how to implement it.
Nevertheless Gee (Gee, 2013) emphasized, that games as a medium are not the guarantor for enhancing a learning environment. The learning system behind a game is crucial for the aspired improvements. The future of new educational methods will be exciting, especially for children and students, as they are given the chance to finally get their motivation back. One can come to the conclusion that across learning environments and educational institutions, a transformation is already taking place. As the game industry can demonstrate a steady increase every year, games and DGBL will definitely have a seat in future educational methods.

3 Learning Analytics

With games being identified as a new, very promising alternative to traditional educational methods, the field of Learning Analytics became more popular as well. Together with Game-Based Learning, the Horizon Report 2012, released by the NMC (New Media Consortium), classified Learning Analytics as a technology to watch out for on the mid-term horizon (Johnson et al., 2013). Learning Analytics (LA) belong to the field of Technology Enhanced Learning (TEL) and deal with the question of how we can understand learning in a more profound way and how to measure the learning process. The relevance of LA can be substantiated by a quote of Phil Long and George Siemens (Siemens and Long, 2011): "The most dramatic factor shaping the future of higher education is something that we can't actually touch or see: big data and analytics".

3.1 Definition

According to Lotze and Tatzal, Learning Analytics help with a better understanding of how learning takes place (Bader-Natal and Lotze, 2011). The Horizon Report (Johnson et al., 2013) defines LA as an interpretation of lots of data produced by students or children, in order to optimize the individual performance or identify potential problems. Romero and Ventura (Romero and Ventura, 2010) classify LA into the field of Educational Data Mining (EDM). However, differences to EDM can be observed. LA is not only about the interpretation of data, resulting in the extrapolation of automated process. To a greater degree, it allows personalized and individual studying. Teachers and educators are presented with data from a single child, which can be used to further enhance the learning behavior (Martin Ebner and Martin Schön, 2013). Another definition from Schön et al. defines LA as a

process, which takes advantage of big data in order to enhance individual learning (Martin Schön, Martin Ebner, and Kothmeier, 2012).

3.2 Learning Analytics in Education

Times have changed. Nowadays, most children or students own a smartphone or tablet (Martin Ebner, Walther Nagler, and Martin Schön, 2012). Even further, internet connection is available in most areas, allowing the usage of internet-based applications. Despite that, Learning Analytics offer various possibilities for primary school education.

To start off, LA allows the creation of tailored educational opportunities (Johnson et al., 2013). This means that teachers and educators are able to tailor educational methods onto individual students. Furthermore, different levels of needs can be satisfied. The New Media Consortium emphasized the possibility of LA to provide real-time feedback. This immediate information may encourage teachers and educators to undertake changes. In addition to that, teachers also benefit from this technology as they can reflect on their educational methods and make adjustments when necessary. Another great possibility is Personalized Learning. Personalized Learning helps to shift the focus of education to the individual child or student, rather than to schools as a whole (O'Donoghue, 2009). The great benefit of this educational approach is that it actually helps realizing a child's potential in different areas, revealing and solving problems. The traditional way of education does not offer such an individual learning experience.

A good example of practical appliance of LA in an educational context is the application Course Signals, which was developed at Purdue University (Arnold and Pistilli, 2012). The primary goal of this program is to reveal students, who exhibit an increased risk of failing a specific course. This derivation is made with a data-mining algorithm. One might think that the interpretation of such data is time consuming and difficult. Course Signals made use of a simple traffic lights system, categorizing students from low to high risk. If the algorithm assigns a student a red light, teachers could interfere at an early time to avoid further problems. The evaluation of

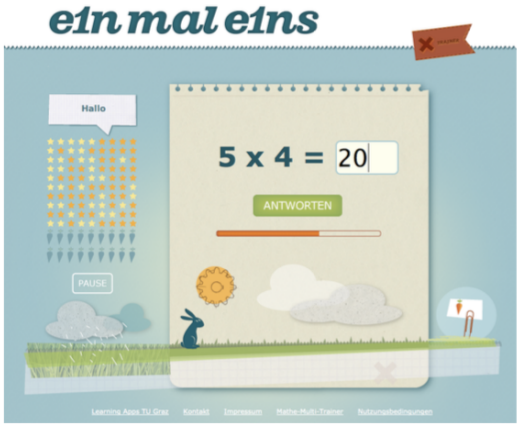

Figure 3.1: Multiplication Table Game developed at Graz University of Technology (Martin Ebner and Martin Schön, 2013).

the project revealed a high accuracy of the data-mining algorithm, which led to crucial benefits for students (Arnold and Pistilli, 2012). Another successful application has been developed at Graz University of Technology. The main goals of the authors were to address the problem of learning the multiplication table in mathematics. According to teachers, this constitutes a major difficulty among primary school children (Martin Ebner and Martin Schön, 2013). Moreover, the authors recognized such weakness as major as multiplication tables are fundamental for further mathematical tasks in the future. To solve this problem, the authors developed an intelligent web-based system for teachers and students. Each child should be able to use the tool in order to improve the learning experience. A web-based application fulfils all these requirements, as it is accessible in nearly every browser. Furthermore, an algorithm was developed to challenge players and encourage them to play more. When a multiplication question was too easy, a more difficult one was chosen next and vice versa. For the analysis of the collected data, each answer to a question is saved in a database. Additionally, the authors developed a management system for teachers and educators, which visualized the results of specific students or classes, as seen in Fig 3.1.. A grid with two axes was used to illustrate the possible multiplications. Colours have been introduced as a signal to warn teachers about specific combinations, which seem to cause problems, similar to the approach of the Course Signal application.

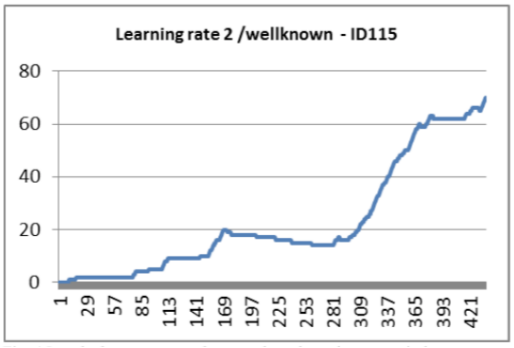

Figure 3.2: Multiplication Table Game Learning Curve/Competence (Martin Ebner and Martin Schön, 2013).

The deducted results of the study showed a significant learning progress among children, as constituted by Fig. 3.2.. After around 300 presented multiplications, an upward trend could be observed. This may not only be caused by the use of DGBL, teachers were able to individually help and support their students.

Learning Analytics is very powerful, as it may not only assist teachers or educators, but also provide valuable feedback on individual students and support personalized learning. However, in the case of the developed multiplication table application, the authors were surprised that teachers were not able to seize their student's problems (Martin Ebner and Martin Schön, 2013). Nevertheless, LA will help shaping the future of education as well as DGBL does.

4 German Language Training Apps [1]

4.1 Motivation

A successful project from Graz University of Technology is the creation of an information system to support personalized learning for children aged 8 to 12. The primary goal is to target the difficulties in the acquirement of reading and writing skills and to further improve these on a sustained basis. When children are grown up, language skills are very important, especially within society. This thesis is about the development of a German language training app prototype for primary school children. As it is conducted at Graz University of Technology, the aforementioned platform called "IDeRBlog" [2] is considered the foundation of this thesis. The following chapters will first explain the importance of mastering German orthography, followed by an explanation of the IDeRBlog. Afterwards, the ideas behind the developed prototype will be elucidated, closely followed by the method of research.

[1] Parts of this chapter have been published in:

Alexander Schwaiger, Markus Ebner, and Martin Ebner (2018). "German Language Training App for Primary School Children." In: Proceedings of EdMedia: World Conference on Educational Media and Technology 2017, accepted, in print

[2] ider

4.2 German Orthography

In 2015 an Austrian survey revealed that numerous primary school children deal with problems in German orthography (Bruneforth et al, 2016). Furthermore it led to the believe that pupils find it especially hard to acquire such skills. In a continuum of orthographies, the so-called shallow ones (Serbian or Turkish) are on the one side, whereas deep ones (English, French) are situated on the other (Markus Ebner, Edtstadler, and Martin Ebner, 2017). It can be said that the German orthography resides in the middle. According to Nerius (Buchmann and Fuhrhop, 2011), this position is determined by the relationship among phonemes and graphemes in the German language. When it comes to articulation, phonemes are the tiniest units, which may cause a different meaning when spelled in wrong way. Such phonemes are connected with the graphemes. Nerius further recognised that German orthography and alphabetic writing systems depend on how good pupils can use the correspondence between phonemes and graphemes. This is especially crucial, as it enables children to convert spoken language into words and in reverse. In a more straightforward way it can be said that children learn these correspondences by time. They gain the ability to transfer spoken words into spoken language and make use of alphabetic strategy (Markus Ebner, Edtstadler, and Martin Ebner, 2017).
Older concepts of learning German orthography focused on the memorization of single words. Children would learn words and the correct spelling by time. However, new approaches appear on the horizon. A promising concept is called "cognitive clarity" (Markus Ebner, Edtstadler, and Martin Ebner, 2017). In this particular method, students are able to recognize the structure behind words (Müller, 2010) and therefore gain more perception of the language (Valtin, 2003). However, an approach like this one is only feasible in classrooms when executed by teachers or students.
Ebner (Markus Ebner, Edtstadler, and Martin Ebner, 2017) gives an example of a very popular phenomenon. When a pupil composes a text and is further asked by the teacher to review the written words in order to find possible mistakes, pupils often do not find a lot of them. Nevertheless, the availability of feedback or various hints assists children with finding much more mistakes than without. Ebner further warns about the difficulty of this method. Teachers and educators do not have the time to teach in a

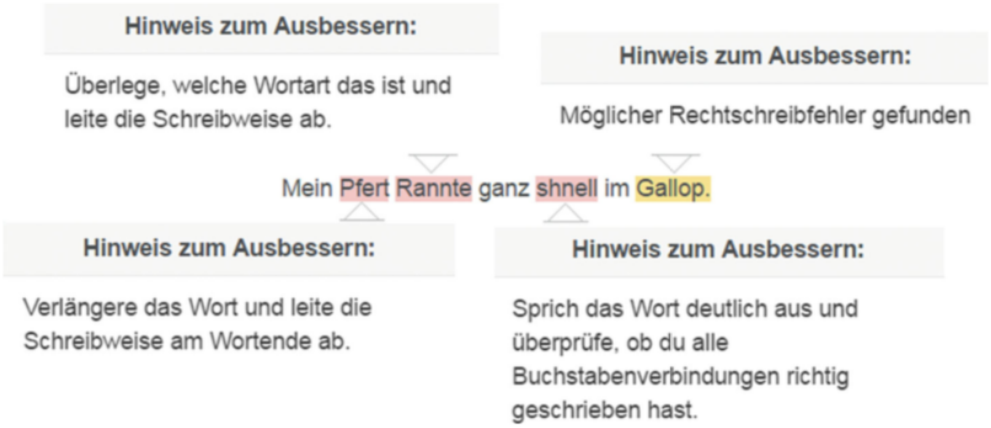

Figure 4.1: Example sentence with multiple hints on the IDeRBlog platform

personalized way, neither do parents have the ability to teach these skills at home. In order to solve this problem, the IDeRBlog platform has been developed.

4.2.1 IDeRBlog

Introduction

The IDeRBlog is an intelligent platform helping children in school to improve their writing skills and to develop orthographic competences. In addition, the platform is developed as a web-based application, meaning that it can be accessed via a browser at any time and anywhere (Markus Ebner, Edtstadler, and Martin Ebner, 2017). The authors also clarify that the main goal of the platform is not to transform writing by hand and replace it with a digital keyboard. To a greater degree, they actively want to make use of the advantages of the digital age. One great feature is the possibility to publish content in different blogs. There can be private, public or specific school blogs so that relevant content can be collected.
Behind the surface of the platform, an intelligent dictionary ensures that multiple analysis is executed to improve language skills (Markus Ebner,

Edtstadler, and Martin Ebner, 2017). While children are only required to know the application of the alphabet, the dictionary offers more features, such as morphological strategies. When a pupil uploads a written text to the platform, the intelligent dictionary identifies spelling mistakes and gives immediate feedback and hints to the author. As children are confronted with their mistakes, they can learn by them and reflect on them afterwards. By doing that, word structures are learned, helping to improve future writings (Tsesmeli and Seymour, 2006). Teachers also profit from the analysis of the intelligent dictionary, as orthographic problems are revealed. In addition, the developers created links between different types of mistakes and the amount of exercises in the training database (Markus Ebner, Edtstadler, and Martin Ebner, 2017) to meet multiple demands.

Design

The design of the IDeRBlog platform for primary school children is crucial, as bad design may cause pupils to stop playing, because they do not enjoy it as much. We have heard before, that learning systems and design are powerful instruments, which decide whether a project is successful or not. As the IDeRBlog platform is developed for children aged 8 to 12, the design of the web interface should be as attractive and appealing as possible for all participating ages (Liebal and Exner, 2011). In addition, children have been actively involved in the design of the platform, as a result of the advice provided by the Horizon Report (Johnson et al., 2013) in 2012. The design and the graphics of the platform have been drafted by a designer upfront. Also, different types of color schemes and assets have been prepared in order to get them evaluated by pupils. After the identification of the most popular one among all participants, the favoured assets have been further developed, modified and integrated into the platform, as shown in Fig. 4.2. Good design also means that the users of the platform can reach the most important functionality within five clicks (Markus Ebner, Edtstadler, and Martin Ebner, 2017). Therefore, the usability of such a platform is crucial for an effective usage. Moreover, the authors state that the combination of appealing graphics and a great usability should create a high engagement among pupils regarding writing texts on the platform. Usability tests en-

Figure 4.2: Creation of the IDeRBlog characters - from a draft to the final version (Markus Ebner, Edtstadler, and Martin Ebner, 2017)

sure that ongoing improvements can be realized and integrated into the platform.

Preliminary Results

The platform went public in October 2016 and initial tests have been conducted at two partner schools by December 2016 (Markus Ebner, Edtstadler, and Martin Ebner, 2017). After the first test period from October to December, 360 texts written by pupils were submitted to the platform. As only two schools actively used the platform by then, this result is very promising, as a high acceptability can be observed. Therefore the goal of using a very appealing design is to encourage students. Moreover, the intelligent dictionary identified 549 mistakes within all submitted texts. Feedbacks and hints could be delivered by the algorithm to nearly a fifth of all spelling mistakes. A deeper analysis revealed that most mistakes could be classified into specific categories. As teachers are able to view a qualitative analysis of all spelling mistakes, they can help students to improve their skills. Also, different exercises are available for children and teachers to advance their language skills. To ensure future optimization, Learning Analytics will be

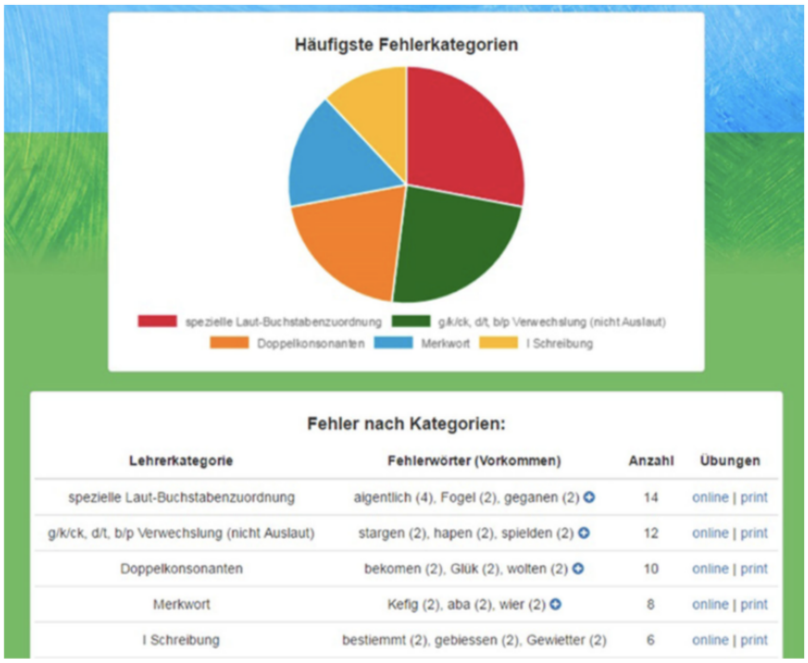

Figure 4.3: Analysis and categorization of identified mistakes (Markus Ebner, Edtstadler, and Martin Ebner, 2017)

used for an in-depth analysis (Siemens, 2012b) to get a better understanding of the difficulties pupils are facing. By collecting a greater amount of data with the increasing number of active users on the platform, a prediction of the children's performance will be made, along with several other features (Markus Ebner, Edtstadler, and Martin Ebner, 2017).

4.3 Research Methodology

Over the last couple of years numerous educational applications have been developed at Graz University of Technology (Ebner, 2015). It is essential to conduct a field test in order to find out whether an application actually can support the process of learning. As mentioned above, the approach and effectiveness of DGBL is strongly connected with key aspects, such as the learning system or the design of the game. Therefore no application can guarantee to deliver educational benefits and help children with the acquirement of new knowledge.

Mobile applications must be evaluated in a practical way, so that useful feedback can be provided. The common way of using the paper-pencil feedback method does not deliver the qualitative information, which is required to provide a valuable evaluation. In the beginning, all children in the classroom were given iPads with the prototype learning app installed. Afterwards, they were asked to play the game for a certain amount of time. During this time-frame, monitoring on how they interacted with the game took place, especially what reactions were caused by different game events and whether there were any visible problems. For documentation and evaluation, images and videos have been taken.

As children are usually shy with researchers and their questions, they may feel uncomfortable very quickly. For this purpose, a separation into groups was undertaken. For the interviews with the children, the ranking technique was selected. In the beginning, each group was given five statements and five smilies. Those questions mainly asked, if they found it easy

to use the game, if they had fun or would like to play the game in the future again. The distributed smilies ranged from a neutral to a very happy one. After each playing session, the groups decided on a smiley for each question, coming up with an ultimate decision that each child agreed on. Afterwards, each working group sorted the statements in a freely chosen chronological order. This method is especially interesting, as children need to discuss and elaborate the game among themselves (Fischer, 2007). In the meantime, the discussion within each group was observed and documented. Through the execution of the cut-off technique, it was possible to observe children in an imperceptible way. Moreover, the children did not feel annoyed or uncomfortable during the field test, leading to qualitative results.

The practical part of this thesis concentrates on the development of a German language training app for mobile devices. As mentioned before, pupils in primary school often deal with problems in German orthography. For this purpose, the developed mobile application has been specifically created to help young children with improving their language skills. Especially the game design and the learning system behind the surface are crucial for positive effects. When games are not fun and engaging, they will not be played any longer. The conducted field study helps to clarify whether this app can provide educational benefits to primary school children.

5 Implementation

This chapter describes the various sub areas of the implementation of the prototype app called ”The Chocolate Fabric”. In the beginning, the design and story of the game will be explained, followed by an explanation of the layout and more detailed insights into the game flow. Afterwards the technology used to develop a cross-platform application for iOS and Android will be introduced and more details on the development of the application will be delivered.

5.1 Motivation and Story

When it comes to the design of a mobile game for children, a lot of different aspects need to be considered. First of all, games only support the process of learning when they are fun to play and encourage pupils to actually play it without being forced. Marc Prensky (Prensky, 2003) expressed his skepticism by composing the statements “academizing games” and “sucking the fun out”. In his opinion, researchers need to be very careful with the creation of educational games, as many neglect the aspects of successful commercial games by making the games not engaging to play. In the chapter about learning systems, some essential characteristics of good games have already been defined, such as regular feedback for players. Those suggestions constituted a solid guideline for the creation of the game design. Successful commercial games do not only gain popularity by delivering a great story or learning system to the players, but also by a beautiful game design, encouraging users to play countless hours.

The main objective of this game is to master diffxerent types of language exercises, in order to collect the ingredients necessary for the production of

Figure 5.1: The start scenery of the game with action buttons

chocolate. Therefore the main scenery of the game represents a journey from a small farm to a chocolate factory, as shown in Figure 5.1. The avatars of the game are characters from the IDeRBlog platform[1], as an important synergy exists between both systems. On the user's way to the chocolate factory, chocolate beans, milk, and fruits can be collected to produce chocolate bars with distinct flavours. When a level is completed, ingredients are awarded to the player. The amount of rewarded beans, milk, and fruits varies depending on the number of correct answer. Within the chocolate creator, pupils can utilize their collectables and compose their own chocolate. The required ingredients are then available in the player's basket. While the number of beans and milk stays the same for all types of chocolate bars, the flavoured ones require different amounts of fruits to be activated.
As games can be overwhelming for children at first sight, a tutorial guides through the initial exercise and the production of a basic chocolate. Multiple pop-overs, containing a short but informative description, bounce in very frequently during this phase and communicate the information necessary to understand the game.

5.1.1 Layout

After the story of the game was ascertained, the layout of the application was constructed. To obtain a better overview of the application a flow chart was created. This chart contains all views of the game and helps understanding the connections. Fig. 5.2 presents the layout of the developed prototype.

Derived from the designed layout chart, the following screens have been defined as necessary:

- Start Screen
- Tutorial Screens
- Exercise Overview Screen
- Right Wrong Exercise Screen
- Upper and Lower Case Exercise Screen
- Completion Exercise Screen
- Bonus Exercise Screen

[1] `http://www.iderblog.eu/`, last accessed at January 22, 2018

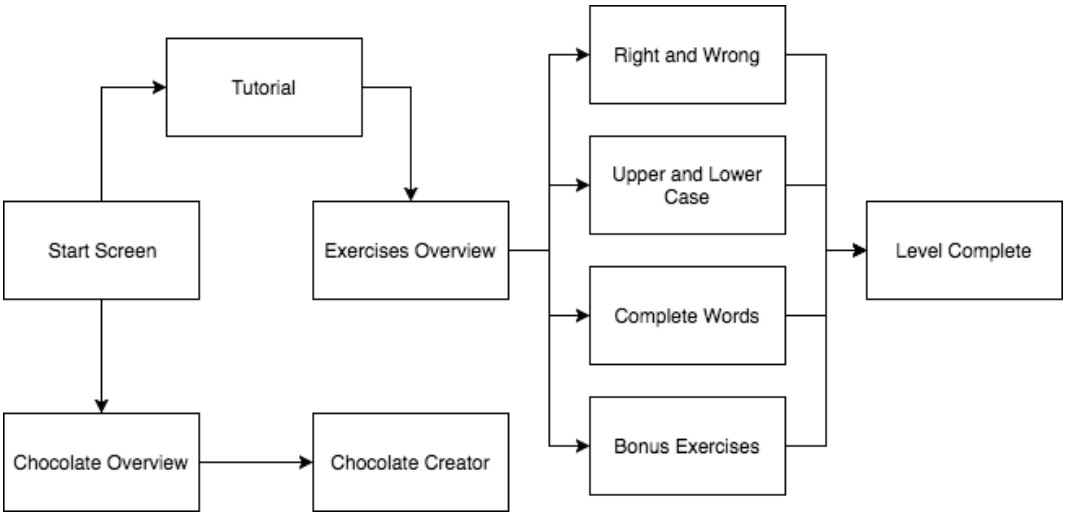

Figure 5.2: The game layout with all views the user can reach

- Chocolate Overview Screen
- Chocolate Creator Screen

Home Screen

As soon as the player starts the game on the device, the start screen appears. This view only serves as an entry point for the player and provides two colored buttons to either switch to the exercises or the chocolate overview. In addition, a less prominent button can be used to turn the game sounds on or off. To retrieve further information on the IDeRBlog project, a small button was placed at the bottom right corner as well.

Tutorial Screens

When the game is played for the first time, a tutorial will be displayed to the player after the play button on the home screen was pressed. This tutorial consists of three informative pop-overs that contain textual information and fade in after each other. A button at the bottom of the information box allows the player to continue to the next one. To explain the story of

Figure 5.3: Superimposed layer in the initial tutorial which helps to explain the story of the game

the game in a childish way, the main scenery was partially darkened and specific layers were superimposed (Fig. 5.3).

The association between text and graphics is established in order to help children understand the story of the game. More detailed information on the tutorial will be given in an upcoming section.

Exercise Overview Screen

The exercise overview screen captures all types of levels that users can play to improve their writing skills. Four large wooden boxes represent these categories, directing the player to the level as soon as they are touched. In

the beginning, only one category is unlocked. After the first five levels of a category are completed, the next exercise category is unlocked. To indicate whether a type of exercise is available or not, a lock image has been chosen. The different types of exercises will be discussed in a following section.

Chocolate Overview Screen

As mentioned above, the primary goal of this game is to collect enough ingredients to produce all twelve types of chocolates. These are visible to the players in the chocolate overview screen. Two columns, each containing six types of chocolate bars, are created to inform the players on their collected chocolates. The collected bars are fully visible, while the uncollected ones are only slightly visible.
To create a new type of chocolate, the players simply need to touch any of the chocolate bars to be directed to the chocolate creator.

Chocolate Creator

The chocolate creator is the main gamification element of this prototype. Within this view, the players can utilize their collected ingredients and produce the various types of chocolates. To avoid any difficulties, a very simple process was developed so that the users are only required to click a few times. The creator only works when enough chocolate beans and milk are available. Optionally fruits can be used to flavour the chocolate.
The functionality of the creator will be explained in a dedicated chapter.

5.1.2 Tutorials and Game Introduction

As Paul Gee denoted in his paper about learning systems (Gee, 2013), regular feedback and tutorials are crucial for good learning systems. Therefore, numerous tutorials were created to help pupils understand and learn the game. When the game starts and the initial screen has loaded, all buttons, except the play button, are locked. In addition, an animation is added to the play button to make it stick out. If a player accidentally tries to enter the

Figure 5.4: Overview screen with all four exercise categories for the player

chocolate creator at first, a pop-over will bounce up and tell the player that the completion of the first exercise is required to continue. This mechanism was installed to first guide players through the game before enabling them to experience everything on their own. After the play button is touched the first time, the main scenery of the game will be shown in addition to three consecutive pop-overs. Via text, these pop-overs explain the story and goals of the game in two to three sentences.

Afterwards, the player is taken to the overview screen, where all types of exercises are visualized, as Fig. 5.4 shows. In the beginning, each exercise is graphically locked and not available. Two seconds after the screen has loaded, the first lock bounces up and unlocks the first exercise category.

When the first exercise is finished, the player is rewarded with ingredients. In general, the awarded ingredients depend on the number of correct answers. However, in the initial level no ingredients are subtracted, no matter how many questions were wrongly answered. The reason for this is that children are taken to the chocolate creator after this exercise to create their first chocolate bar. As each chocolate requires a certain amount of ingredients, it is likely that some children fail to achieve the required amount in the initial level and therefore get confused. By this approach, pupils are guided to the chocolate creator with the ingredients in their basket. The chocolate creator is then explained step by step with informative pop-overs. This tutorial explains how a chocolate bar can be created and collected.

Before an exercise starts, a wooden board indicates the number of collectables in this particular level. The board includes a short text to motivate the player and three columns underneath, which represent chocolate beans, cows for milk, and fruits. A bouncing button is placed at the bottom to start the game. After an exercise is finished, the same board is shown to the player with the number of awarded ingredients.

5.1.3 Types of Exercises

Before the development of an application can take place, the types of exercises need to be worked out. Especially in DGBL, the learning system needs be thought through, as the main goal is to support pupils in the process of learning. As this thesis focuses on the improvement of German language skills, the following four categories of levels were defined:

1. Right and Wrong
2. Upper and Lower Case
3. Completion of Words
4. Combination

The following sections will explain the four categories in a more detailed way and further clarify, why they have been chosen.

Right and Wrong

The idea behind Right and Wrong questions is to see whether children can identify a word's correct notation. In the first step, a specific word, e.g. "Laufen", is chosen by the background logic of the application. Each word contains a pool of common incorrect notations and is constructed from the data available on the IDeRBlog platform. With the help of a probability function, an algorithm decides the word to be displayed. This word can either come from the pool of wrong notations or it is the correct word. This approach helps to see if pupils encounter difficulties with specific words or learned words with an incorrect notation. In the previously mentioned example of the word "Laufen" the algorithm could either choose "Laufen" or a randomly selected one like "Laufhen". In order to keep it simple, two buttons can be used by the player to decide whether the displayed word is correct or not.

When an answer is given, the background logic evaluates the decision and directly provides feedback to the pupils. In the case of a correct one, a message will be displayed in an animated way to get the user's attention, highlighting that a correct answer was given. In case of an incorrect one, a message will bounce up as well. In addition, the original accurate notation will be displayed so that pupils can learn and remember the precise notation, as shown in Figure 5.5.

Upper and Lower Case

The level category Upper and Lower Case confronts primary school children with the challenge of completing selected statements. Each statement requires a decision whether upper or lower case syntax must be used regarding a specific word. The intention behind such an exercise is to help children learn specific grammar rules, such as nouns in German are always written in upper case notation, independent of the positioning in the statement. At

Figure 5.5: User feedback for an incorrect answer on the "Right and Wrong" exercise

Figure 5.6: Example "Upper and Lower Case" statement with the available user options

first, random sentences are selected from a database and prepared for the exercise. The searched vocable from the chosen statement is then removed by an algorithm. For example, the vocable "Tür" would be replaced by "ür (t/T)", as Figure 5.6. visualizes.

Two buttons at the bottom present the two possible answers. Upon a user selection, the game integrates the chosen notation into the statement and points out the result in the same way, as the Right and Wrong category does. With this type of exercise, pupils are encouraged to think about statements and their context in a deeper way.

Figure 5.7: Example "Upper and Lower Case" statement with the available user options

Completion of Words

The third elected category challenges pupils as words miss out an important character and need to be completed by the players. Numerous German vocables appear to be tricky to write for young children. Therefore the primary goal of this exercise is to support children in writing these words correctly. After a subset of words has been chosen by background logic, a crucial character of the word is removed and further replaced by a question mark, as shown in Figure 5.7. The players are then required to tap into the question mark box, causing the device keyboard to show up. Children then can type in the missing character they consider to be correct. A button at the bottom of the screen can be used to submit the answer. If an answer was correct, complimenting feedback is shown to the user. If the chosen

character is not the right one, the correct word bounces up in the same way as in the other exercises.

Combination

This type of exercise is a bonus level and encompasses right and wrong, upper and lower case, as well as word completion tasks. The primary goal of this conjunction is to confront children with all exercise variations at once. Furthermore it helps to train pupils in learning difficult words, which have been conspicuously answered wrong. As each player is associated with a unique device ID, an algorithm in the background keeps a dictionary on each word. This dictionary includes information about the number of wrong attempts and can be used to promote individual learning. If a single vocable is not answered correctly, a counter will be increased. This allows the use of a ranking technique, as especially difficult words for the player are delivered in the different types of levels.

5.1.4 Chocolate Creator

The main gamification element of this prototype is the ability to create chocolate with different flavours. As children play the game and finish off exercises, they are awarded with ingredients. These can be used within the creator to produce a milk chocolate and eleven flavoured ones. For the production, chocolate beans, milk and optionally fruits are necessary. From the main menu, players can visit the chocolate page which provides an overview of all collected bars, see Fig. 5.8. By pressing one of the bars, the game switches to the creator. The chocolate creator is designed in a very simple and easy to use way. It is especially important that children do not experience any difficulties in this particular aspect as the collected chocolates encourage them to play more games. An error in the design needs to be avoided as it could lead to a loss of motivation.

The initial view of the creator consists of a top bar where the current amount of ingredients are displayed and a big wooden box to create the chocolate.

Figure 5.8: Overview of all collected types of chocolates

Figure 5.9: Chocolate creation board with the required ingredients

The box includes a chocolate bar that waits to be pressed by the player. After touching the chocolate bar, the chocolate creation board bounces up, as Fig. 5.9 indicates. For each required ingredient, a round button with a plus symbol is placed at the bottom of the board. By pressing the buttons, the necessary ingredient is selected for the production. Beans and milk must be added to create a basic milk chocolate. To diversify the chocolate, a fruit can be selected to add flavour the chocolate bar. After the user made his decision, a large button must be pressed to start the creation of the chocolate. An animation is displayed to user to represent the production.
The main goal is to encourage children to collect all types of chocolates. As at least a hundred exercises need to be completed to produce all types of chocolate bars, a lot of data can be collected by the game.

5.2 Database of Words

One of the most challenging tasks in the creation of a game that supports learning is to measure if actual benefits can be delivered by the game. As stated in the introduction, the delivery of personalized content to players is of special interest. In addition to that, data needs to be collected and evaluated to identify if there are educational benefits. Primary school children possess a certain vocabulary that constantly improves when they get older. It is crucial to use appropriate exercises that can help children to improve their writing skills as otherwise they might easily feel overwhelmed. Learning benefits may be destroyed even before the game is played.
The first encountered difficulty of the developed game was the best possible distribution of words presented to children. For instance, children aged ten or older might easily solve exercises that are not suited for younger or older age groups. It was crucial to develop a method that allows to distribute an appropriate difficulty among all players of the game and therefore deliver the right words to the different age groups.

In the beginning, all players are identified by their device identifier. This unique number does not contain any information about the player, such as name or gender. All the collected data is collected in a completely anonymous manner and therefore does not allow to connect certain results with real persons. Before the first level of the game starts, the player is asked to select his age in order to proceed. The following age groups to choose from are available for players:

- Age 0-8
- Age 9 to 10
- Age 11 to 13
- Age 14 or older

After the players have selected their age group, the game can start and appropriate data is individually selected for the player. The words for this prototype are derived from the dictionary of the IDeRBlog platform. This relationship provides a great value as the data is directly fetched from the pool of frequently incorrect spelled words among the users of the game. As mentioned before, children use the IDeRBlog platform to upload their

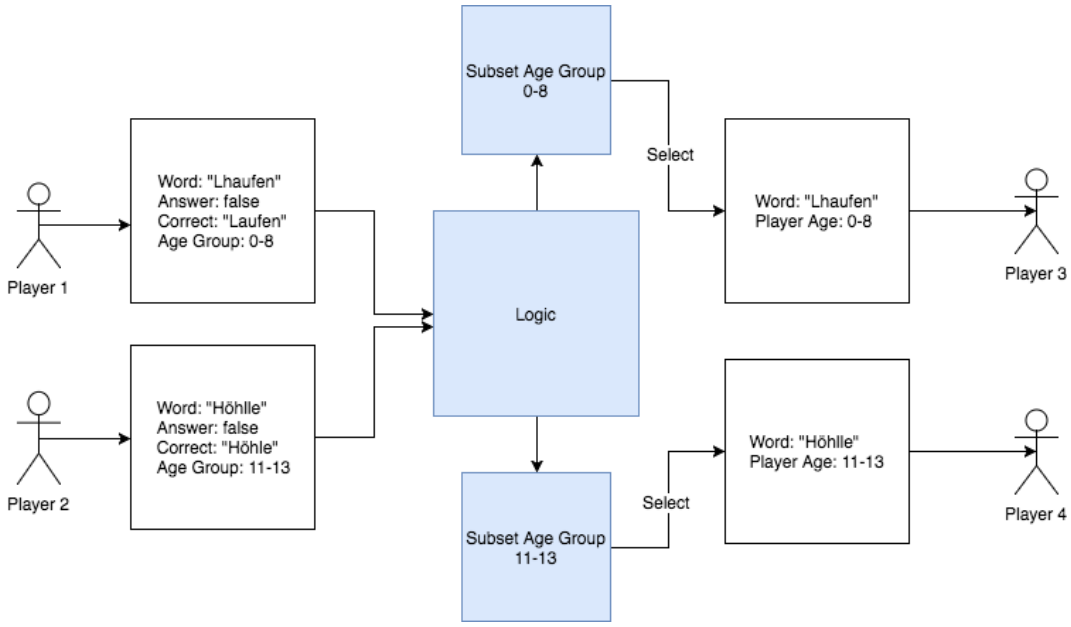

Figure 5.10: Personalized data selection for specific age groups based on data analysis

written texts. An algorithm checks for mistakes in the statements and provides immediate feedback to them. Therefore the IDeRBlog system can provide a suitable pool of common incorrectly written words for the game. For the different exercises in the app, the words are chosen based on the provided age of the player. The results of each practice round are send back to the IDeRBlog system for evaluation. Based on the answers from the pupil, new words are chosen for the following exercises. The link between the game and the IDeRBlog is considered extremely valuable for both systems. They profit from each other as more data is collected in the background to foster better exercises. Furthermore, the quality of the game is increased as the previously gained knowledge helps in the realization of educational benefits.

A second approach to deliver meaningful data is the creation of a sub-dictionary system. Whenever a child completes an exercise, an algorithm in the back checks all decisions of the player and whether they have been

answered correctly or not. In addition to that, an association with the age group enables the creation of a sub-dictionary for each individual age group. This correlation allows to identify specific words or statements that are considered especially difficult for certain age groups. Figure 5.10 visualizes this algorithm with multiple inputs.
It can be stated that the game collects individual learning data that is associated with the age of the pupil. Therefore the words and challenges for the different game categories can be delivered in a personalized and best possible way. While not only children benefit from this approach, teachers also get an insight on the altering difficulties among the various age groups of their pupils.

5.3 Cross-Platform App Development with Apache Cordova

When it comes to the development of mobile applications, two main approaches can be identified. One is to develop applications in a native way. This means that developers write code for both iOS and Android apps individually. This results in two different code bases and requires double the effort. The maintenance costs also increase as updates and bug fixes have to be implemented for both platforms. Nevertheless, the native approach still offers various advantages as developers get access to the operating system functions. Additionally, powerful developer tools have been created by companies like Apple or Google.
Despite the native approach, a second one is currently seeking more attention. This one concentrates itself on the creation of cross-platform applications. Such applications, often called hybrid ones, are developed once for multiple platforms and therefore eliminate the prerequisite of writing unique code for each platform. If it is essential to support multiple operating systems at once, this approach delivers multiple advantages in terms of maintenance, scalability or expandability.
The Chocolate Factory prototype is developed as a hybrid application and uses Apache Cordova as a base framework[2] to support both iOS and An-

[2] `https://cordova.apache.org/#getstarted`, last accessed on January 28, 2018

droid operating systems.

5.3.1 Cordova

Cordova is an open source framework that was created by the Apache Software Foundation[3] to develop cross-platform mobile applications. In opposition to native development languages, like Swift for iOS and Java for Android, this framework uses classified web technologies as HTML5, SCSS, and JavaScript. Apache describes Cordova in the following way: "Cordova wraps your HTML/JavaScript app into a native container which can access the device functions of several platforms. These functions are exposed via a unified JavaScript API, allowing you to easily write one set of code to target nearly every phone or tablet on the market today and publish to their app stores."[4]. The following subsections will shortly explain the main components of a hybrid architecture. Furthermore, Figure 5.11 gives an overview of the various elements that this architecture brings along.

WebView

The WebView is used to display the user interface. It can be described as the component that is responsible to visualize the developed application to the user.

WepApp

In cross-platform applications, an application is embedded as a web page. Typically the default file, called "index.html", contains all the links to the various stylesheets , JavaScript files and all other resources which are used by the app. The application code itself is located in the WebApp. On the surface, cordova applications can be considered native as a native wrapper is generated at first when the code is compiled. Afterwards, the web view is

[3] `http://www.apache.org/`, last accessed January 29, 2018
[4] `https://cordova.apache.org/#getstarted`, last accessed January 28, 2018

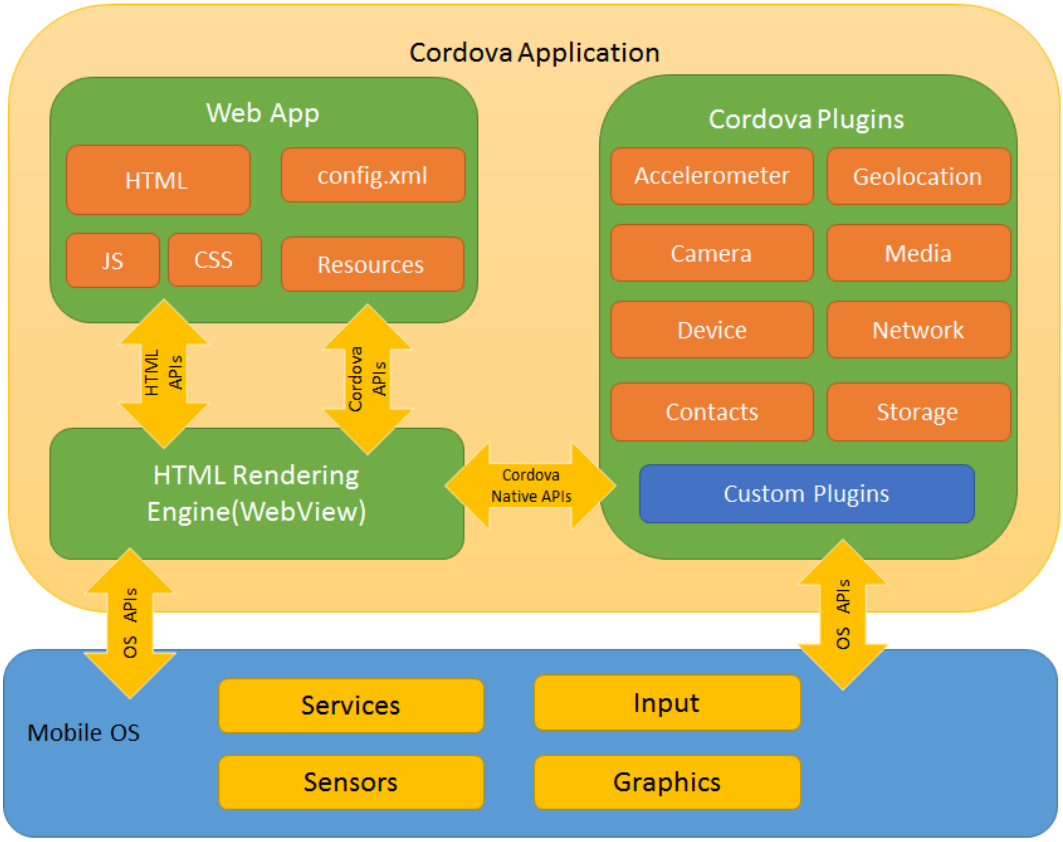

Figure 5.11: Architectural overview of Cordova applications[5]

placed into this wrapper. This means that cross-platform applications are web-based applications and are just disguised as native ones.

Plugins

Plugins are a very important element of cordova applications as they provide an interface to the native functions of the device operating system. Core plugins of cordova enhance developers with the ability to access information like the battery status, the ability to use the device camera, and other specific functionalities. Furthermore, there exists a large range of different plugins that are mostly open-source projects and can be downloaded with the JavaScript package manger "npm"[6].

5.4 React

Cross-platform applications are developed with popular web technologies like HTML, SCSS and JavaScript. For the development of this protoype, the library React[7] has been chosen. React is a JavaScript library that is primarily used to create user interfaces. It is developed and maintained by the software company Facebook and features a large community as well as an active ongoing development. The advantages of this framework are the clear separations within complex user interfaces. These divisions allow to develop applications in a clean and structured way. With React, large chunks of code in single files can be avoided and maintenance is improved as the code base is distributed among multiple files.

5.4.1 Mode of Operation

With React, JavaScript files render HTML code into the Document Object Model (DOM). This happens through the render function and results in the

[6] `https://www.npmjs.com`, last accessed January 28, 2018
[7] `https://reactjs.org/`, last accessed January 28, 2018

creation of an element tree. Whenever elements in the tree are changing, React determines the most effective way to update the DOM and the associated elements. This update does not result in a completely new render process. In fact, only the changed tree elements are replaced by an algorithm. Engineers at Facebook had to deal with the long runtime of the algorithm in the beginning. The transformation of one tree into another tree causes a complexity of $O(n^3)$[8]. A tree with 1000 elements then would cause a billion steps of comparisons which they did not consider as acceptable in terms of performance. With the assumption of two rules, a new heuristic algorithm could be developed with a runtime of O(n):

1. Elements that are not of the same type will cause a different tree
2. Developers can use a key to mark specific elements as stable

The first assumption refers to the change of an element type. If an image tag is placed inside a HTML div tag that is then changed to a span, the tree is completely rebuild. During the destruction of the old tree, elements will be completely reset and data will not be saved.

```
1
2  // old tree element
3  <div>
4    <image src="image.png" alt="dummy" />
5  </div>
6
7  // new tree element
8  <span>
9    <image src="image.png" alt="dummy" />
10 </span>
```

Listing 5.1: React example that causes a full render cycle

The second assumption deals with an arrangement problem. Whenever React encounters a list of items in the DOM, an update will cause the algorithm to compare item by item in the old and the new tree. For example, if an element is appended at the end of the list, React simply adds the new item to the list as all previous ones exactly match when compared with each other. However, if an element is inserted at the front, a mismatch on the first element occurs and any further comparison fails due to this mismatch.

[8] `https://reactjs.org/docs/reconciliation.html`, last accessed January 30, 2018

This leads to a complete recreation of the whole element tree. The following example visualizes this dilemma:

```
1
2  <ul>
3    <li>Alex</li>
4    <li>Valentin</li>
5  </ul>
6
7  // no problem as the elements Alex and Valentin match in the
       beginning
8  <ul>
9    <li>Alex</li>
10   <li>Valentin</li>
11   <li>Peter</li>
12 </ul>
13
14
15 <ul>
16   <li>Alex</li>
17   <li>Valentin</li>
18 </ul>
19
20 // rebuild the tree as Alex from the old tree and Peter
21 // from the new tree do not match as first elements
22 <ul>
23   <li>Peter</li>
24   <li>Alex</li>
25   <li>Valentin</li>
26 </ul>
```

Listing 5.2: Using keys to avoid a re-render on stable elements

To address this issue, keys have been introduced by the engineers at Facebook. If each element is in possession of a key, the algorithm can match the elements by this identifier to efficiently compare both trees and avoid the recreation of the tree. Keys can be added simply adding the key attribute to the HTML element.

```
1
2  <ul>
3    <li key="person1">Alex</li>
4    <li key="person2">Valentin</li>
5    <li key="person3">Peter</li>
```

```
6 </ul>
```

Listing 5.3: List with keys for stable rendering

5.4.2 Components and Pages

In React, the main elements to build applications are components and pages. These are usually identified by developers at the very beginning of the development after the design of the application has finished.

Components

Components are used to encapsulate functionality within React applications and to build pages. Typically, components are developed and tested separately from each other and are later wrapped into pages. It can be said that a component represents a specific piece of logic, such as an input field handler for example. Additionally, each component maintains a state that is used to store variables and data within the instance. This store of data is not shared among others and is specifically bound to a particular instance of a component. The following code snippet demonstrates an example of a simple React component that maintains a state with a variable that is displayed to the user:

```
1
2  class ShowNumber extends React.Component {
3    constructor(props) {
4      super(props)
5      this.state = {
6          numberOfExercises: 4,
7        };
8    }
9
10   render() {
11     const { numberOfExercises } = this.state
12     return (
13       <div>
14         The number of exercises is: { numberOfExercises }
15       </div>
```

```
16      )
17    }
18  }
```

Listing 5.4: Component with a state variable that is rendered

Variables of the state can be used and changed by developers at any time. Whenever a state variable changes, React automatically recognizes this event and checks if the DOM needs to be rendered again. If the changes do not affect the displayed interface to the user, the DOM is kept the same as performance improvements can be realized this way.

If a component is used within other components or pages, it is sometimes necessary to pass data into the component. This is done through so-called properties that are written into the HTML tag declaration. Properties symbolize input data and also cause the DOM to render upon changes, similar to state variables. If a component has both properties and state variables, it is called a stateful component. In contrary, simple components may not provide any functionality and are just used for displaying information. This code snippet demonstrates the mark-up of a component with two properties:

```
1   render() {
2     return (
3       <div>
4         <DummyComponent
5             examplePropOne={1}
6             examplePropTwo={[1, 2, 3]}
7         />
8       </div>
9     )
10  }
```

Listing 5.5: React component with two properties

Components represent the key elements of the React framework. Most applications consist of a lot of different components. A more detailed insight into the structure and use of components in the developed prototype app will be given in the next chapter.

Pages

A page is a wrapper for a specific user interface. In terms of functionality, a page is basically the same as a component. However, developers can use pages to organize and structure their code much better than without. Furthermore, global data is bundled inside pages and then routed into components that require specific data to operate on. This is best explained by an example. Nowadays many applications require the user to register within the application before getting full access to it. Therefore an identified page could be the register screen. In addition to that, this screen mostly contains input fields for the user to enter his personal data. Some applications may even take it a step further by asking the user to upload a profile image for instance. In React, an input field or the camera upload functionality would be swapped out to individual components. These components are independent of the page and can be used randomly wherever they are needed. The page is in charge of handling the data flow and often takes callbacks from components. In case of the camera upload component, the page would receive a callback with the image data for example.
Typically there exists a page for all views of an application.

5.4.3 Redux

In React, global data is stored inside the store. The store can be accessed by dispatching actions to it. To manage the store efficiently, the Redux JavaScript library[9] technology is used for this prototype. With the help of Redux, components and pages can dispatch actions to mutate the store. Each action is identified by a certain key and may include a payload. To avoid bugs and further issues, the store can not be changed as only read requests are allowed from the outside. To handle all the dispatched actions, a reducer must be created. A reducer receives action after action and performs the proper data mutation, therefore managing the complete state of the app.

[9] `https://redux.js.org`, last accessed January 30, 2018

Redux[10] defined itself by three core principles:

1. It exists of only one source
2. The data store only allows for read-only access
3. Pure reducers allow for the mutation of the store

The first core principle refers to the store of the application as it can be described as an object holding the application state tree[11]. Within an application, there only exists one store.
To ensure that no unwanted actions or network calls mutate or change the application state, changes can only be performed by dispatching actions to reducers. This is the second core principle of Redux. In addition to that, all actions are objects that can be easily logged and debugged for further testing in the development.
The last principle takes a spin on the received actions. Each reducer receives two function arguments when being called. The first one is the previous state, the second one the dispatched action object. Typically the key of the action is matched in the code and the necessary mutations of the state are performed. At the end, the reducer returns a new state object.
The following code shows how an action can be dispatched and then matched by the reducer. In this case, an integer is simply increased by the value one.

```
1  // dispatch the action to increase an integer by one
2    store.dispatch({
3    type: 'INCREASE_INTEGER_BY_VALUE',
4    payload: { value:  1 },
5  })
6
7  // sample reducer with a switch-case statement to catch all
       dispatched actions
8  function sampleReducer(state = 'SAMPLE_REDUCER', action) {
9    switch (action.type) {
10     case 'INCREASE_INTEGER_BY_VALUE':
11       // build the newState and return it
12       const newState = state.integer + action.payload.value
13       return newState
```

[10] https://redux.js.org/docs/introduction/ThreePrinciples.html, last accessed January 30, 2018

[11] https://redux.js.org/docs/Glossary.html#store, last accessed January 30, 2018

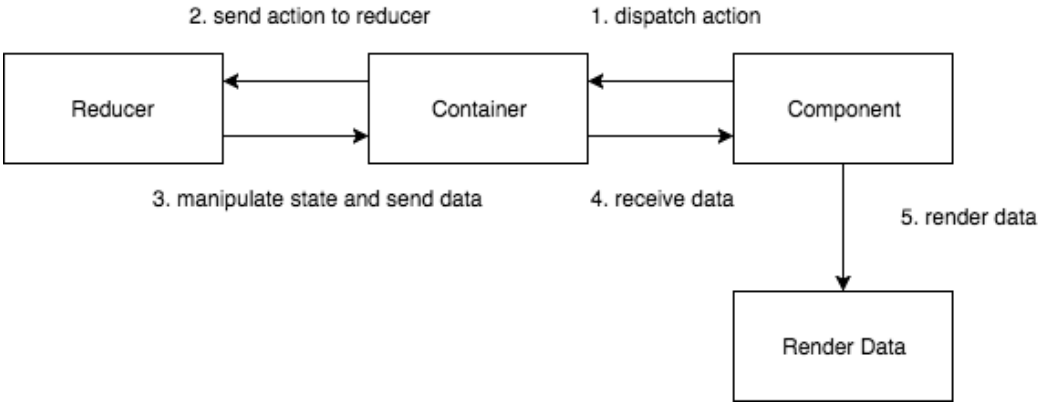

Figure 5.12: Relationship between a reducer, container, and component

```
14      default:
15        return state
16    }
17  }
```

Listing 5.6: Redux handling example of a dispatched action

5.4.4 Container

As for now, pages and components have been explained as the primary elements to build applications with react. Furthermore, they need to dispatch actions to reducers in order to change the store. Reducers are responsible for the handling of the application state. They control the incoming actions and manipulate the state if requested. Situated in the middle are the so-called containers. Containers serve as an interface for components and pages to dispatch actions. In addition, they provide a connection to the store such that global data from the store can be used inside the component or page as a property. (Fig 5.12).

Components, containers and reducers all work together as a closed system and interact with each other heavily. The next section will present selected code examples to demonstrate how all these technologies are united with each other.

5.5 Development of the Prototype using React

This section explains the implementation of the prototype app with the JavaScript library React. At first, the basic structure of the code will be discussed. Afterwards, implementation details and selected code examples will give insight on how pages, components, containers, and reducers have been used to develop the game.

5.5.1 Overall Structure

After the design of the game was finalized, the implementation of the game was ready to get started. The code project structure was set up at first to obtain a good overview of the project:

- Pages
- Components
- Containers
- Reducers
- Assets

In the next step, all pages of the game had to be identified according to the design. Subsequently, a JavaScript file was created for each page. Afterwards it was necessary to think about all required components. Especially the possibility to use a component more than once within a project makes it difficult to identify generic components. Nevertheless, all components could be discovered and a JavaScript file was created for each of them as well.
Past to the identification of the components and pages, the containers had to be created. Usually, each page is in possession of a container as well. Components however do not often include a container. Callbacks, data sets, or functions are often bundled inside pages and then sent as properties into components. Therefore component containers are only created if a component is considered highly independent and needs the ability to dispatch actions to the reducer.

5.5.2 Implementation of Right and Wrong Exercises

The developed prototype offers three types of learning exercises and a combination of these as a fourth one. In this chapter, the implementation of the "Right and Wrong" learning exercise is described. Therefore the created pages, components and containers will be explained in order to provide insight on how the development with React and Redux was conducted. In addition to that, code snippets are used to communicate a better understanding of the prototype.

First of all, a connection to IDeRBlog API had to be established to construct the database of words. At first, a GET call was implemented to fetch the required data from the server. Similar to dispatched actions from components, API responses are also forwarded to the reducer as soon as they arrive. Upon a successful request, the received data is checked against errors and further prepared as it is written into the global store afterwards (Code listing 5.7). To access the data in components and containers, each dataset is connected with a specific key such that a key-value pair is constituted.

```
1
2  function apiReducer(state = 'API_REDUCER', action) {
3    switch (action.type) {
4      case 'getRightWrongData':
5        if (action.response.accepted) {
6          const data = action.response.rightWrongCollections
7          return state.set('rightWrong', fromJS(data))
8        }
9      default:
10       return state
11   }
12 }
```

Listing 5.7: Parsed API response in the reducer

Followed by the establishment of the connection, the functionality of the exercise had to be designed. The basic idea is to confront children with one word at a time, getting them to identify if the displayed word is written correctly or not. Two buttons can be used to mark the word as correct or incorrect. After an answer is submitted by the player, the next word needs

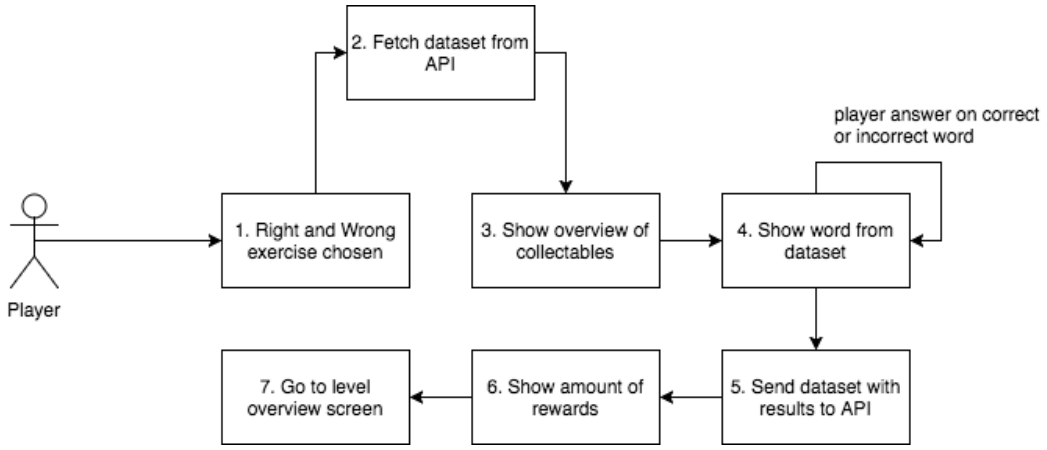

Figure 5.13: Game flow describing the "Right and Wrong" learning type

to be shown. In addition to that, an informative board at the beginning of a level informs the players on the number of collectable beans, milk, and fruits. Similarly, the awarded ones have to be shown after all answers were collected. To avoid mistakes in the design and concept, a flow chart was created (Fig. 5.13).

The following elements were created after the structure was determined:

- Component - Collectables Overview Board
- Component - Right and Wrong Exercise
- Container - Right and Wrong Category
- Page - Right and Wrong Category

Collectables Overview Board Component

The collectables overview board is presented to the players two times. Once before the level starts and then after it was finished. The content inside the board consists of a motivational quote, images for all types of collectables and the amount that can be collected for each as well as a button to dismiss or continue the game. In order to make the component work, some properties have to be passed into it. First, a flag is used in order to indicate whether the board is shown before or after the level. Secondly,

the amount of collectables are passed into it. This data can then be used to display the amount of each collectable. The last required property is a callback function that notifies the parent component or page that the user clicked the button in the board. Therefore a function pointer is sent from the parent component into the child component.
The following code snippet illustrates how the component can be used by other components and how data can be accessed inside it.

```
1  // usage from outside passing properties to the component
2
3  <CollectablesBoard
4    data={[ { beans: 5 }, { milk: 10 }, { fruits: 20 } ]}
5    levelFinished={false}
6    callback={() => levelFinished()}
7  />
8
9  //  inside the component
10
11 render() {
12
13   //  access properties
14   const { data, levelFinished, callback } = this.props
15   return (
16     <div onTouchTap={() => levelFinished()}>
17         // conditional statement
18         { levelFinsihed ? <span>Success!</span> : <span>You can
               do it!</span> }
19         <span>{data.beans}</span
20         <span>{data.fruits}</span
21         <span>{data.milk}</span
22     </div>
23   )
24 }
```

Listing 5.8: Usage of the overview component

Right and Wrong Exercise Component

This component contains the main logic behind this exercise type as words are displayed sequentially after each other and user answers have to be verified against mistakes. Generally the component only takes two properties

as inputs. The first one is the dataset of words that was initially fetched from the IDeRBlog API. The second property is a callback function that is triggered when all answers were given by the player.
The data structure of a single word entitiy is of special interest. Each word is an object that contains a set of commonly wrong written words. As mentioned before, the IDeRBlog dictionary receives a lot of written texts and performs analysis on that data to identify incorrect spellings. Each vocable is therefore associated with a collection of wrong variants that can be used to see whether children can identify them as incorrect. An algorithm in the prototype decides, with the help of a probability function, if the correct syntax of the word or an incorrect one is displayed to the player.

After a child has submitted an answer, the component checks for the correctness of the decision. To start off, each word object is mutated in the beginning to keep track of all necessary informations. In addition to the correct syntax and the alternative spellings of the word, a flag is used to capture the decision of the probability algorithm. With the help of this boolean, the answer of the player can be verified. The presented code snippet illustrates in an abstracted way how the logic was implemented and how actions are handled within React components.

```
1
2  setAnswer(answer) {
3
4    //  check the result of the answer
5    let result = true
6    if (word == correct && answer == no || word != correct &&
         answer == yes) {
7      result = false
8    }
9
10   //  create a dataset with the word and the answer
11   let dataSet = {
12     wordObject: word,
13     answer: result,
14   }
15
16   //  save the result
17   saveDataset(word)
```

```
18
19    if(word == lastWord) {
20      //  trigger callback
21      this.props.levelFinished(allResults)
22    }
23  }
24
25  render() {
26    const { word } = this.props
27    return (
28      <div>
29            <span>Is this word correct: { word } ?</span>
30            <Button value="yes" onTouchTap={() => this.setAnswer(
                 true)}>Yes</Button>
31            <Button value="no" onTouchTap={() => this.setAnswer(
                 false)}>No</Button>
32      </div>
33    )
34  }
```

Listing 5.9: "Right Wrong" implementation example

Right and Wrong Container

Containers are used as a middleman between components and reducers. They allow to dispatch actions in order to send data to an API or conduct data manipulations in the store. On the other hand, containers are necessary for components to access data in the global store. A container can map the global state to properties which can then be used inside the component as properties.

```
1
2  // get the dataset of words from the global store
3
4  export const mapStateToProps = (state, ownProps) => ({
5    words: state.get('rightWrong', List()),
6  })
7
8  // actions that are dispatched by the component
9
10 export const mapDispatchToProps = (dispatch) => ({
11
```

```
12    sendUserResult: (payload, resolve, reject) => {
13      dispatch(sendUserResult(payload, resolve, reject))
14    },
15  })
```

Listing 5.10: Example of a React container

A container generally only has two primary functions. The first one is called ”mapStateToProps” and is responsible for receiving data from the global state. In the code listing above, the dataset of words for the right and wrong exercise is obtained with this function. The component is then able to use this data as a property variable. The second function ”mapDispatchToProps” defines outgoing actions that are dispatched by the component. In the example above, a function to send the user result is created. To demonstrate how these properties can then be used, another code listing is provided:

```
1
2  //  usage of defined functions
3
4  if (levelHasFinished) {
5    // dispatch the created action
6    this.props.sendUserResult(data, success, failure)
7  }
8
9  // usage of data properties
10
11 const data = this.props.words
```

Listing 5.11: Using container properties in components

In other words, the container makes all required data from the global state available and accessible by using the prefix ”this.props” inside the component. Further, the actions to be dispatched to the reducer are called with the same prefix as well. In this particular exercise type, the main props are the retrieved dataset of words and a defined function to send the user result to the API as soon as the level was finished by the player.

Right and Wrong Page

The created page for the Right and Wrong exercise type is used as a wrapper for the previously described elements. Through the associated container,

the required data and functions are made available. The intention of a page is not to implement masses of logic and functionality but to coordinate the flow of actions that are triggered by components. The following piece of code illustrates the page structure of the Right and Wrong language exercise:

```
1
2  //  callback from the CollectableOverviewBoard component
3
4  levelBoardClicked() {
5    if (this.props.levelFinished) {
6      // return to level overview screen
7    } else {
8      // start the level
9    }
10 }
11
12 //  callback from the RightWrongComponent
13
14 levelCompleted(data) {
15   //  dipsatch the result to the reducer and send data to API
16   this.props.sendUserResult(data)
17 }
18
19 render() {
20
21   //  access the database of words and the level state from the
         global store
22   const { words, levelFinished } = this.props
23
24   return (
25     <div>
26         <CollectableOverviewBoard
27           levelState={levelFinished}
28           data={words}
29           callback={() => this.levelBoardClicked()}
30         />
31         <RightWrongComponent
32           words={words}
33           callback={(data) => this.levelCompleted(data)}
34         />
35     </div>
36   )
```

```
37 }
```

Listing 5.12: Right and Wrong page structure

The right and wrong component with all the logic and the overview board of collectables are placed in the render method in order to be integrated into the DOM. Both components are then rendered and made visible to the user at runtime. The overview board requires two parameter to work. First, the database of words is passed into it. Secondly the current status of the game is used. As explained earlier, this component is utilized before and after a level is completed and therefore needs to know whether a level is running or was finished. In addition to that, a callback will be triggered when the overview board is clicked away by the player. This action then triggers a page function to redirect to the home screen.
The right and wrong component also receives the database of words as a property. A callback is provided to indicate that all answers were submitted by the player. A page function then takes care of the user result and calls the previously defined property function to dispatch the results.

6 Research Study [1]

Finally, we conducted a field study among children in the second grade of an Austrian primary school to test our prototype for the first time. In total, 16 children were participating in the test with a balanced distribution among 10 male and 6 female ones. In the beginning, we introduced the app to the children, primarily to help them to find and to start the game on their tablets. An Internet connection was already established before the field study in order to avoid any unexpected problems. This encouraged the pupils to start playing the game directly. As the game uses the device number as identifier, no registration process or other authentication was required. Therefore, no difficulties have been observed in the first steps.

While most of the children easily managed it to play the game and finish off their first exercise, some children experienced difficulties with the provided tutorial in the game. "What should I do?" was the most frequent asked question among children experiencing troubles. The tutorial mainly explains the purpose of the game and visualises it through textual information. However, children just clicked on the continue buttons and paid not much attention to such information. Within a game session of 30 minutes, all participants submitted around 1900 answers. This impressive ratio leads to the conclusion that the game design worked very well and research team showed that children faced some challenges with pressing the buttons accurately. Sometimes a touch did not trigger an action and required them to press again. Increasing the touch area of buttons definitely will solve this problem. The game idea of collecting ingredients and creating flavoured

[1] Parts of this chapter have been published in:

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chocolate bars was considered as positive. Nevertheless, the chocolate creator in the game demonstrated some problems. The first monitored issue pointed out that the children mostly tried to drag elements rather than push the designated buttons. ”How can I produce chocolate?” was asked by multiple children, demonstrating that improvements need to be made to the creator. Furthermore, the path from the game’s home screen to the chocolate factory was not highlighted enough for the children. The research team observed at some point, that children helped each other out with the challenging exercises they were confronted. There was also a positive rivalry among some male players on the current level or progress, as Fig. 4 shows. It led to believe that the original intention of producing all types of chocolate was substituted by the number of collectables.

After the game session was over, we asked the children to form groups and discuss about certain statements as described in the previous chapter. The following statements were prepared:

1. The game was easy to play.
2. I liked to play the game.
3. I find it great to produce my own chocolate.
4. The exercises are easy for me.
5. I want to play the game again.

With the help of the cut-off technique, the children discussed their point of view in the group for some time and then started to assign the smileys to the questions. Three out of five groups voted the chocolate creator as the best feature of the game. The other two groups liked to play the game and wanted to continue playing. Some children even asked the teacher to continue playing after the game session was over, showing a strong interest in the game. On the other side, two groups found it not as easy as others, to operate the game. One child stated: ”It was very fun to play the game and I would like to play it again”, confirming an interest to play the game again. The observation helped to identify that different language skills among the children caused the problem. While some found the games easy to understand the words and exercises, some struggled with the presented exercises, as their vocabulary was not advanced enough.

As disclosed before, 1900 answers were provided by the pupils during a 30 minute session of playing the game. A closer look on the collected data showed a balanced distribution among all played types of exercises. In total, 68% of all answers given were correct and only 32% incorrect. An interesting fact is the positive development throughout the game session. The available data led to the positive finding, that an increase of 15% in correct answers was observed in the second half of the 30 minute session. This indicates that children already started to improve their skills as previously incorrect words were answered correctly in consecutive exercises.

7 Conclusion [1]

This thesis paid attention to the use of German Language Training Apps in Austrian primary school classes. A prototype language trainer was developed for iPad tablets and evaluated by a conducted a field test in a second grade class. Sixteen pupils participated in the game session and completed nearly two thousand tasks within half an hour. With the help of the cut-off technique, valuable feedback was obtained as children discussed about the game in an unobserved way. Especially the connection to the IDeRBlog platform is of special interest as many data is collected in a short period. This data is provided to the IDeRBlog system and further improves the platform as new analyses can be conducted. Learning Analytics benefit as well from the new sets of data and therefore more value is added to the accuracy and performance of the platform. This ensures exercises that are more appropriate in the future and deeper insights into spelling mistakes made in the defined age areas.
While the game showed great interest among pupils, still some crucial factors to think off can be suggested to developers of educational games. The usage of lots of textual information is not effective as children simply click through all types of tutorials. Therefore, learning by doing seems to be a good approach. They also favour to drag elements rather than touch them. In addition to that, a game should notify the players upon important events and provide call-to-action components to directly switch from the current state. It can be concluded that children need guidance through the game.

Overall, we suggest the use of game-based learning in primary school

[1] Parts of this chapter have been published in:

Alexander Schwaiger, Markus Ebner, and Martin Ebner (2018). "German Language Training App for Primary School Children." In: Proceedings of EdMedia: World Conference on Educational Media and Technology 2017, accepted, in print

as children really enjoy playing games on their tablets. Furthermore, it could be observed that children did not feel annoyed by a learning game at all, thy rather enjoyed it very much.

Appendix

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