Game Design Patterns for Learning

The research reported in this thesis was carried out at the Open University in the Netherlands at

Centre for Learning Sciences and Technologies
celstec.org

under the auspices of

SIKS

Dutch Research School for Information and Knowledge Systems

and as part of the ICOPER project.

Typeset in LaTeX
Cover design: Sebastian Kelle

SIKS Dissertation Series No. 2012-41

ISBN: 978-3-8440-1372-6

Game Design Patterns for Learning

Proefschrift

ter verkrijging van de graad van doctor
aan de Open Universiteit
op gezag van de Rector Magnificus
Prof. mr. A. Oskamp
ten overstaan van en door het
College voor promoties ingestelde commissie
in het openbaar te verdedigen

op vrijdag 9 november 2012 te Heerlen
om 13:30 uur precies

door

Sebastian Theodor Walter Kelle

geboren op 12 juni 1979 te Freiburg, Duitsland

Promotor:
Prof. Dr. M. Specht
Open Universiteit

Co-Promotor:
Dr. R. Klemke
Open Universiteit

Overige leden van de Beoordelingscommissie:

Prof. Dr. M. Pivec
Joanneum University of Applied Sciences, Graz, Austria

Prof. Dr. M. Wolpers
Fraunhofer Institute for Applied Information Technology (FIT), St. Augustin, Germany

Prof. Dr. L. Bijlsma
Open Universiteit

Prof. Dr. S. Brand-Gruwel
Open Universiteit

Preface

This doctoral thesis is the result of a PhD project lasting from 2008 to 2012. With finishing this large piece of work, one of the questions that came to my mind is how all of this came about and what happened in the beginning.

I first came across the topic of game-based learning when I was doing some exploratory research on how to use Second Life for e-learning purposes. After preliminary steps of getting acquainted with the content production on this platform I was invited to join the Prolearn Summer School 2007 in France, on which I got first ideas going into the directions that ultimately led to this result.

Coming originally from the rather technical field of Business Information Systems and Cryptographic Communication Systems, I encountered the European community of "technology enhanced learning" as a group of highly active enthusiasts of social and welcoming nature with a rich wealth of inspiring power – In fact, more resembling a bunch of artists than scholars.

While discussing the topic with my new acquaintances I got the idea of so-called "provocation based learning", which targets the fact that learning (and especially e-learning) often is all but engaging. The idea was to draw the attention of the learners by confronting them with something outrageous, unexpected and motivating. It quickly became clear that these elements of "provocation" possibly could be something that relate to some more fundamental concepts in motivational aspects of learning. Following this lead I got more and more into the field of game-based learning and the idea of mapping game design patterns onto educational patterns was born. The idea was so straightforward that I was quite convinced that this had been already done before, however, it turned out that something like a well defined and reusable approach did not exist yet.

This is the basic rationale in this thesis. The genesis of so-called "Game design patterns for learning" we might also call "Game Learning Patterns".

One of the challenges was to develop a new kind of taxonomy that did not contribute to further complication of the already quite complex field of game-based learning. As is the case with many theories and paradigms the applicability is the main crux (for example in the ICOPER project on standards in e-learning, we had the paradox of having to create yet another standard that standardizes all standards).

Some certain approach for game-based learning might work well in a particular context (for example, medical training), but fail in any other. Other unpredictable factors are not helping either: what about the users? Are they young, old, impatient or stressed? What about their taste and sense of humor?

Using a fair range of analytic ordnance, it was possible to stay on top of these imponderabilities. The results may in fact bear more new questions than answers, but have the potential to inspire hapless learning game designers to achieve successful results.

For me, this whole thing started with getting inspired, and my mission was to give back something inspiring to the scientific community. Perhaps, this work can.

Acknowledgments

For opening doors and inspiration I would like to express my gratitude to

Fridolin Wild, Katherine Maillet, Ambjörn Naeve and my dear friend from the Arctic regions: Steinn Eldjárn Sigurðarson.

I would like to thank the following people whom I met while working at CELSTEC and who became my good friends and supporters, often encouraging me and making times together a great experience:

Dirk Börner,
Halszka Jarodzka,
Bernardo Tabuenca,
Charlotte Wolff,
Kamakshi Rajagopal,
Victor Alvarez,
Christian Glahn,
Marion Gruber,
Wolfgang Greller,
Milos Kravcik

Special thanks go to

Wolfgang Rheinhardt, for editorial advice and answering an important LaTeX question,

Christine Geserick, for artwork and photography as well as some idea hamstering, and keeping the door open to Vienna,

Adam Sporka for his phenomenal enthusiasm about science that infected me,

the teachers Dominique Verpoorten and Guido van Dijk for kindly inviting me to their schools and allowing me to run experiments with their classes,

Hub Kurvers, Wim Van der Vegt and Aad Slootmaker for their competent help with the software implementations,

Roland Klemke, Wim Westera and Marcus Specht, for sacrificing their nerves and patience, so the project could actually be completed,

Jo Boon and Rob Koper for their protective interventions when the project was under fire,

Alice Boereboom-Pierey and Nicole Knebel, for taking care of all the administrative magic flawlessly,

Rob Nadolski, for giving valuable input during the proposal phase of this project and finally taking a good look at the Dutch version of this work's summary,

Also, I would like to express my gratitude to my family and White Bite & Co for their trust and support, especially during the end phase of this project when I had to relocate. This was a huge help.

Last but not least, I would like to give credit to Mieke Haemers for the great help with organizing everything, for the exciting times together, and for being the best person in all of CELSTEC.

Contents

Part I.

Theoretical Context

Chapter 1.

General Introduction

One of the striking observations when looking at the roots of games and learning is that its definition and background oddly go beyond the human aspect of learning sciences. Animals (in essence, all placental mammals) have the ability and the drive to learn through play (Burghardt, 2005). Zoological research illuminates the importance of play for young animals to learn essential skills (Hawes, 1996). Gaming, hence, is a very natural way of self-directed learning during a phase in life, which is the stage of most rapid cognitive development. Therefore it is safe to assume that game-based learning has existed for a very long time going back to prehistoric times. Being a subspecies of the class of placental mammals, also young humans engage upon their drive to learn by gaming. The natural drive to learn through play, however, is coerced by modern society. Acknowledging the obvious demand for games that is a culturally universal phenomenon, the notion of learning through games, though, has a somewhat unserious flavour, especially from the perspective of formal educational systems.

In life-long learning, however, education is usually not formally imposed on the learner. There is a high degree of "ownership of learning" that turns the situation around (Wilson et al., 2009). The learners themselves are now the main motivational instance and equipped with a fair deal of initial self-motivation. Much like subscribing to a gym, this initial motivation can, however, decrease quickly when they discover disadvantages, like getting bored or overtaxed.

The main objective of a game-based learning approach for life-long learning, thus, is the sustenance of this motivation and helping learners over the hurdle of getting truly comfortable with the overall learning process they have engaged upon. While this may seem like straightforward goal, the challenge is far from trivial.

For several years, experts in the field of education have made thousands of games designed for education, however, mostly the advantages of such an approach have

[0]This chapter is partly based on: Sebastian Kelle, Steinn E. Sigurðarson, Wim Westera and Marcus Specht (2010): Game-Based Life-Long Learning. In George D. Magoulas (Ed.), E-Infrastructures and Technologies for Lifelong Learning: Next Generation Environments. Hershey, PA: IGI Global.

remained obscure, and the factors required to successfully create a learning game out of a situation are seemingly random (O'Neil et al., 2005). In this work we introduce a systematic approach that makes use of game design patterns (Björk and Holopainen, 2004) for gamification of educational systems. These can be used for the following purposes:

- Identifying hidden game elements in a non-game-based educational scenario,
- Gamify existing learning content and educational solutions,
- Designing a game from scratch out of efficient and functioning game patterns, fulfilling a certain purpose and for a defined goal.

Based on this systematic approach we also hope to find successful gamification patterns or as we will introduce later, "Game Learning Patterns" for the gamification of learning solutions aiming at certain positive effects and primary and secondary learning objectives.

1.1. Life-long Learning with Digital Games

The state-of-the-art of games in life-long learning is difficult to pinpoint, as scientifically relevant results on the exact intersection of the two spectra are scarce. However, there exist some approaches that can be placed in the topical proximity of our focus, showing very promising perspectives. We selected these examples as they illustrate different extensions of life-long learning settings making use of game patterns or game-structures.

One of the more notable approaches, for example, can be found in the field of mobile learning games dealing with the life-long learning of the homosexual minority in India (Roy et al., 2009). The targeted people have the societal disadvantage of being pushed into obscuring their sexuality from daily life, which makes it difficult for them to access relevant knowledge that could help them avoid related problems such as HIV infection or drug abuse. While the learning game as such makes use of the pattern of role play, hence enabling a good deal of identification with the game character, it is also a way for the target group to stay anonymous: the game is realized as text message based quest game, moderated by anonymized "peer educators". The users can play the game accessing relevant educational content without revealing their personal attitudes to their social surroundings: operating a mobile handset is nothing that draws a lot of bystanders' attention. The pivotal gaming factor in this example is the role-play pattern, which enables the players to take on the role of a "peer educator" who gives clues and interesting quests to other players, or vice versa. The mobility of the game is as such not the main factor, but makes the game accessible at low-cost (unlike, for example, laptops, cell phones are widely distributed among all kinds of social tiers). While this example may seem very specialized and unique, it illustrates the enormous potential of a game-based life-long learning approach.

Another, example with more generic properties is the “UniGame” described by Pivec and Dziabenko (2004). In this approach, several teams collaborate on a simulated project, for example the building of a tunnel. The team that produces the best project plan to offer to an imaginary stakeholder wins. Each team gets a certain amount of “chips”, which need to be used to allocate limited resources for emphasizing certain topics over others. Indeed, team-play is an inherent component of many games. In this example the main game objective and activity includes quite a variety of secondary learning objectives and users learn a lot of social and secondary skills beside the main activity focused around the game objectives that are related to knowledge management.

An example that builds on an existing LMS (Moodle) is a web-based personal glossary and quizzer module built as plugin (Sigurðarson, 2008). The glossary offers support to create on the fly a quiz from either a single user’s glossary or all users’ existing glossaries, to test their skills at translating words from one language to another. A choice is made on how many words to include in the quiz, and after completing one, the users are able to see how fast they completed it, the percentage of right and wrong answers, as well as which words they translated correctly and which not. Other indicators can for example make use of the “high score list” pattern, visualized as a current placement indicator, akin to those found in racing games, displaying “3rd” or “1st”, depending on a player’s current position. Their words per minute can even be displayed with a mock speedometer. Scores and competition are another inherent component of most games and can be quite powerful tools for motivation and feedback in educational games.

There is also a variety of games available that offer a big potential for use in education: location based games making use of latest mobile technology. According to Grohé (2009), already a small but fair choice of games exist that make use of location based services, using the Global Positioning System. The games mentioned by Grohé are “Fast Foot Challenge”, “Geocaching”, “GPS:Tron”, “REXplorer”, “Gowalla”, “Mobile Dead”, “The Go Game” and “Metal Gear Solid: Portable Orbs”, all of which make use of the possibility to monitor the player’s geographical location in relation to other game elements (other players, objects). As a more recent example, the mobile game prototype “WeBuild” (Schmitz, 2012) was developed in order to ease the access to educational content for disadvantaged learners, by minimizing the entry barrier level. The game was applied within the domain of building industry and showed positive learning outcome and user acceptance.

Summing up, the possibility to use the games listed for learning emerges from their social and geographical dimensions: being able to experience real life situations creates a strong immersion factor, while virtual mobile indicators augment those situations with important information needed for the game experience. For example Geocaching, the oldest and most widely used location based game of the lot, uses a quiz pattern for people to figure out the coordinates of a cache (a physical treasure hidden somewhere). In this case, we already have to deal with a sub-game, which can be used for learning. After that, the exploration and cooperation pattern is being extensively used to put together a team of explorers who head out to find the cache, which might even be hidden in locations that are very difficult to access: For example, there are caches on Antarctica, Mount Everest or under water. In sum, location-based games offer the potential of games linking game-logics and situated learning support with its rich features for authentic and embedded learning activities.

Game patterns play an important role in all these games and there is a direct impact of different types of games on lifelong learning. The main innovations can be seen on the lines of

- mobile games embedded in social context,
- embedded teamplay for training social skills you such as "Massively Muliti-player Online Roleplay Games (MMORPGs),
- score based games, that use high scores embedded in learning as social motivating factors
- adaptive storytelling and story-based games

The examples listed above highlighted some dimensions of the integration of games in life-long learning scenarios. In the following section we would like to outline some effects and added values of game structures in life-long learning.

1.2. Advantages of Games in Life-Long-Learning

Although above examples show a big potential, it might not be immediately clear what makes learning games specifically attractive for use in the life-long learning context. The reasons are of practical nature: people who are already working in a full-time job ideally combine their life-long-learning activities with recreational activity, which is in line with the notion of informal learning (Coffield, 2000; Foreman, 2004). On the other side of the coin, especially in times of world economic crisis people lose jobs and often have to start over, trying to get qualified in different areas or getting back to school to get the degree they never completed. This is how life-long learning and formal education encounter and create a potentially painful combination. Especially for people who already have been in a workplace and gathered professional experience, getting "back to school" may be perceived as big throwback.

We theorize that especially under these conditions, learning tends to reside down in the lower end of the enjoyment scale, while games and other frivolous activities rank higher. A reason for this could be that learning is usually understood by authorities, and experienced by people as the passive act of "receiving" knowledge from a speaker, text or video in a formal setting (of a school or institution). Enjoyable side-activities happening within this context, such as socializing or even playing games are usually discouraged or forbidden, a state which increases their scarcity, and thus their value. However, the pleasurable value of learning is greatly decreased by the stark contrast to the individually more valuable, discouraged activities happening in between lessons or classes (Schank and Cleary, 1995).

Due to these very reasons, many researchers in the field of pedagogy have struggled for years to show that what is happening within the classroom is not "really" learning (Illich, 1971) (also supported in a more recent article by Hart (2001)). It is simply a structured way of delivering information, in the hope that through a process of content delivery, and repeated exercises, with their respective mistakes and successes, the participants get a proper understanding of the topic at hand. This system roots in the introduction of factories during industrialization (Peters and Keegan, 1994), and by now many educators believe that a more flexible approach, harnessing the power of the Internet and computers, for example, clearly offers better alternatives.

We acknowledge and build upon the fact that formal education is perceived by most as an unpleasant activity, and a great many learners spend most of their cognitive power "playing the system". This is a problem we refer to as Naeve's knowledge emulation problem (Peña-López, 2007), which appears to be centered around the testing aspect of formal education. Tests, usually few of which will have an actual impact on a learner's grading, are spaced out far enough from each other, to give the teacher ample opportunity to design the tests, as well as to review the student's scores. The possibility of repeating an exam or a test of the same nature is rarely offered, causing many learners to struggle finding ways of emulating the knowledge at all costs, since failure is not an option. According to Naeve and Peña-López, this behaviour unfortunately means that many learners avoid reflective thinking or contemplation on their subjects, as they are more concerned with passing these "rare" tests and avoiding any delays in their career, than mastering their subjects.

This presents one of the major challenges for modern educators, to break free of the factory-mentality of formal education, and restore fun and discovery to the learning process. One way to accomplish that is to add gaming elements to an existing learning activity. An approach to do so is using generic game patterns as explained below.

Games by their very nature are often simulations of real world activities, or simply "naïve" problem solving enhanced by instant gratifications in various forms:

points or audio/visual “rewards”. A simple method for turning exercises into a game is the introduction of a scoring system. A scoring system allows a learner to gauge their performance from exercise to exercise, as well as enabling comparison to their peers and thus competition.

Even the most simplistic scoring system may revitalize a learner’s efforts as they offer easy alternatives to the sparsely taken and heavily weighted tests mentioned earlier. In stark contrast to those, learners are put in charge of personally reviewing their own performance in each task, reflecting on it, and possibly redoing the task to improve their performance. This reflection and the critical thought involved in analyzing a past performance, what went wrong, or what may be improved, is a critical part of the learning process. While this perspective can be interpreted as formative assessment, another type of scoring system can also be found in formal educational scenarios. In that case the score is kept in form of grades, i.e. summative assessment (Harlen and James, 1997). Here, the learning experience is more rigid and any positive experience or outcome can be suppressed by knowledge emulation, which suggests that a lifelong learning context is a more fertile environment for our direction.

1.3. Identifying motivation drivers: Competition, Collaboration and Indicators.

Psychological research has revealed several factors influencing human performance both positively and negatively in relation to gaming (Becker, 2005). These factors are either in line (positive) or in conflict (negative) with the findings of educational research on motivation theory (Keller, 1983), experiential learning theory (Kolb, 1984) and instructional theory (Gagné, 1965). Considering how these approaches complement each other, we believe that there are only few main drivers responsible for games being as engaging as they are, and people are not equally affected by them.

The first of these factors is the ability to see progress in an obvious and continually available manner. When users are able to gauge their progress and realize the effects of their actions with regard to any type of measurement (usually realized as “points” in a game) this introduces the first and most basic form of gaming: the ability to compare performances. In formative assessment, this notion is related to direct feedback (Sadler, 1989) while in this case the feedback cycle is minimized. Additionally, this first factor holds true whether the person is alone, comparing their performance to their own previous ones, or in a group and comparing with others. The moment we, however, introduce more people into the activity, a myriad of possibilities appears as many are more easily motivated in direct competition with others, than just with themselves. Competition between people can take many forms, one of which is already realized by the first factor: the ability to compare your performance to others and to put their performance into context (a principle that has extensively been researched by Glahn (2009)).

Things start becoming interesting when actions of a player can influence the performance of others. This paradigm is common and at the core of most competitive games. Examples from a few different styles of games are:

- In a first person shooter video game a possible influence is to destroy other players' avatars, and thus causing them to lose their weapons/items they have accumulated, as well as increasing own score, for example by picking up items dropped by another player who got "destroyed".

- In a game of competitive Tetris, by eliminating the gaps in a line on the screen, a player causes a new line of blocks with random gaps to appear on the other player's screen.

- In a game of soccer, each player is able to intercept the ball whenever it is passed around the field, and even to intercept players of the opposing team and outplay them for the ball.

A second factor would be the ability to affect the performance of others. Now, this may seem like a factor, which is not too easy to include in simpler settings, but as we will demonstrate there are several patterns or ways to achieve this kind of competition. In scenarios where there are more players than two, this type of patterns introduces another aspect of gaming, which is the opposite of competition, namely collaboration.[1] However, while the element of competition is a strong driving force of a game, collaboration between players can provide so much mutual benefit that players who choose not to play as part of a team are greatly disadvantaged. Upon forming of teams in games, there is also an element of in-team collaboration that has a competitive aspect of players of the same team comparing their stats, forming a sub-game out of the overall game.

A third and very crucial factor is the challenging role of being in charge. Game worlds have a high potential to simulate the notion of control and ownership to the player. This is especially notable in role play scenarios where the identification with the game character is fostered. However, consequences remain in-game and have no effect on the player in terms of real risks, which therefore gives the player more freedom to try out different tactics and develop own ways to solve problems.

Finally and most obviously, the "game content" itself is an important factor. If a certain innovativeness and aestheticism is warranted, the gaming experience is more attractive and the player enjoys exploring (Kiili, 2005). These simple

[1] Other factors play a role as well, such as problem-solving (e.g. Sudoku) or killing time (Solitaire)

additions to any activity are powerful ways to motivate participants in exciting new ways. A common problem of many medium to large enterprises is a varied workforce in terms of age, gender, originating cultures and professional abilities. There are those within each workforce who are threatened by the idea of competing with their co-workers, especially in a learning scenario. Maddock (1999) states that mostly males under the age of 50 enjoy pure competition, while other groups either prefer competing with their own performances, or working and competing in teams. In a team scenario, those who are not necessarily under the impression that their own performance is the best, may still play an important role.

In the text above, we briefly mentioned indicators and the important role they play in providing one of the basic elements required for gaming: a scoring system. Scoring systems may however be constructed in a variety of ways, ranging from a simple dichotomy, where a participant is either successful or not, to the more common "points" system, where a linear number denotes performance, to the most complex scoring systems, where a score is given in any number of different areas of game-play (multi-vector score systems).

Examples of these more elaborate scoring systems are, for instance, found in many strategy games, where players are awarded a number of points in areas such as resources, how well they exploited the resources available, unit production, unit destruction, building production, and destruction. A very elaborate system of scoring each match is being deployed in many multiplayer action games, such as Halo 3 (Thompson, 2007). In Halo 3, different scoring systems apply depending on the type of game being played. Although each player receives a general score for performance based on the number of times a player destroyed another player, there are many rewards to be achieved, and after a match is completed, players are able to review and reflect upon their "kills/deaths" ratio, their accuracy or favored weapons, and even which opponents they most often clashed with successfully or unsuccessfully.

According to Lynn (1991), it is a fact that humans give objects value based on their scarcity, so a reward for an "excellent" performance should be hard enough to achieve for it to be valuable, while not being unattainable and thus demotivating. A prime example of the relationship between scarcity and value is that of a rare gemstone (aesthetic value aside, let it be a raw stone): its value is directly linked to its scarcity, to the fact that not everyone can obtain it. The same is true for virtually anything, points or rewards in a gaming scenario are only worth the effort involved with acquiring them: the lesson we learn is that even if a reward has no real value, it will be valued simply due to its scarcity. In fact it may be argued that when turning real-world tedious activities into a game, rewards programmed into the game should not be valuable in the real world, and if so only as a token. Increasing the stakes too much will decrease the gaming factor.

Now, we have established one aspect of indicators, and one of their main functions: to indicate a player's score. Additionally, the indicators themselves may have reciprocal properties. An important dimension of any indicator in a technology-enhanced scenario is the timing of display. When engaged in an interactive activity, which may or may not be competitive, the factor of whether or not the performance may be gaged in real time is an important one for the overall experience, as seeing a clear indicator of your performance at each given time may encourage or discourage depending on the person. This may be viewed similarly to a speedometer or an odometer, or both. Seeing the current speed and total distance traveled while cycling, for example, is very useful for cyclists who know they need to cycle 20 kilometres in one hour, so as long as their speed is 20km/h or more, they may feel secure and motivated to keep their pace, if they are unable to keep such a pace, however, this indicator could affect their performance negatively: a principle that is called formative feedback, as discussed by Mory (2004).

1.4. A brief appetizer on “Game Learning Patterns”

There is already in-depth research done on design patterns for learning purposes, for example as conducted in line with the EU Kaleidoscope project (Mor et al., 2006). However, under the notion of game patterns we understand game design patterns (Björk and Holopainen, 2004) as used in conceptual game design in its broader sense. They are used for matching learning scenarios with implementable game elements to enhance the scenario. To conceive this, we suggest a content based approach that gives us the possibility to come up with an instructional design in connection to the story line of a respective game. The possibilities for this are context dependent, relating to what is the desired main educational outcome. As a choice derived from fundamental pedagogical theory, as described by Robinson (1998), learning goals can be subsumed as:

- The acquisition of information
- The practice of tangible skills
- Training of problem solving and collaboration

Depending on this classification, as well as the respective learning context and domain, it is decided what kind of game should be used (Quest type, real world simulation, highly reaective multiplayer game, etc.) and what will be the respective game elements. To do so, game design patterns are chosen that form the actual game design by being combined with each other, for example resource patterns, stating the score of players’ attributes, able to be traded, lost or gained. The fundamental difference between software design patterns used for building learning environments, such as suggested by Retalis et al. (2006), is that game design patterns are in fact used for an earlier stage than actual application development. The patterns are meant to help a conceptual game designer to spawn a combination of game elements that works well to achieve a learning objective. As will be shown in chapter 2, there exist some leads to start from.

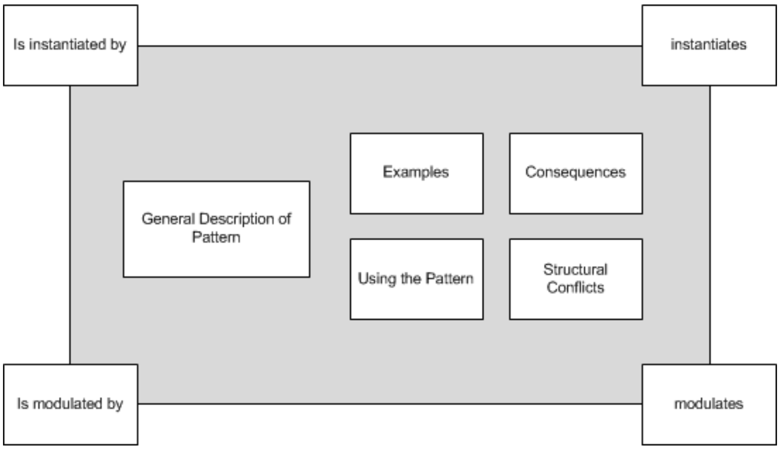

Figure 1.1.: General structure of a game design pattern, according to Björk and Holopainen (2004).

As sketched in figure 1.1, game design patterns consist of different structural components. First, the core of the pattern describes its functionality, what element of a game it represents, how it is used and what the consequences are. Also possible conflicts with other game elements are indicated lest they appear in the same game together. Relating to this, a metric of combination rules applies: patterns can be combined by modulation (one pattern influences the other), and instantiation (the existence of one pattern leads to the coexistence of another). In theory this construct leads to "game based" compound learning objects such as described by Boyle (2003), however in a less concrete form. It is, however, important to stress that a single game pattern does not suffice to create a whole learning game. Therefore it should be argued that the metrics for combination are of paramount importance for a sound game design. The specifics of software design, derived from a conceptual design, can be extended to fulfill the requirements for implementation by using a layered composition of elements as suggested by Boyle. Another point is that the reverse engineering of existing game-based learning scenarios may elicit game elements that have already shown to be of educational use and can then be mapped to form the appropriate contextualized taxonomy of game patterns for learning (Becker, 2007).

Some of the more versatile examples are social interaction patterns, such as competitive patterns and collaborative patterns.

> **Example:** The "Cooperation" pattern: "Players cooperate, i.e., coordinate their actions and share resources, in order to reach goals or sub goals of the game." (Björk and Holopainen, 2004)

To form a game out of this starting pattern, it is necessary to instantiate into more specific patterns that state fact about how in detail the cooperation is conceived. "Alliances", "Team Play" and "Shared Rewards" could be possible sub-patterns. In juxtaposition of aforementioned pattern, the "Competition" pattern is of relevance:

> **Example:** The "Competition" pattern: "Competition is the struggle between players or against the game system to achieve a certain goal where the performance of the players can be measured at least relatively." (Björk and Holopainen, 2004)

This pattern, for example, is instantiated with the "Enemies" pattern, "Player Elimination" or "Incompatible Goals" patterns, only to name a few self-explaining examples.

As pointed out above, an important element is the reflection of the player's progress or status, which can be achieved by making use of resource/score patterns, raising the awareness of success and failure, especially when it comes to social comparison. Finding the right selection of game design patterns according to the classification mentioned above (acquisition of information, practice of skills, collaboration) can be systematized in conjunction with the pedagogical processes relevant to the learning scenario, and comparing these requirements with the description of the game design patterns in question. For example, the acquisition of information (a process critical for learning) can be reflected in-game by the "gain information" pattern, a pattern which is described as the goal of performing actions in the game in order to be able to receive information or make deductions. To foster collaboration, the "shared rewards" (The players who were involved in some way in reaching a goal in the game share the reward.) pattern may be of use, while the practice of a tangible skill could be reflected back to the learner in terms of progress and success indicators, such as "score" or more specifically "high-score-lists" as such introducing a competitive element.

While this procedure illustrates how one pattern leads to another, it is important to balance the game patterns in such a way that a residence within the bandwidth between engagement and on the other hand content is achieved: Learners should be motivated and "drawn" into the game, but not be overly distracted from the learning goal. It is a matter of ongoing research to find out which learning functions best profit from what game design patterns calculated over the broad range of suitable domains and contexts as well as target audiences. A way to do this, according to our preliminary findings, is to match game elements with pedagogical processes using pedagogical taxonomies as intermediary step.

Figure 1.2.: The mapping between pedagogical functions, pedagogical taxonomies and game design patterns representing the corresponding game element after implementation. Note that a game element can be composed of a combination of game design patterns.

As will be explained in chapter 2 in more detail, figure 1.2 shows how such a mapping is carried out. The pedagogical taxonomies mentioned are largely based on the theories by Gagné (1965), Keller (1983), and Kolb (1984). Additionally, the classification of Heinich et al. (2002) (educational design theory), and Robinson (1998) (pedagogical goals) can be considered. Indeed, comparing these taxonomies with above mentioned classification of game patterns, a striking similarity becomes obvious. As will be explained in the upcoming chapters, a rich variety of game design patterns can be directly mapped to instances or concepts of those pedagogical taxonomies.

Example: With respect to dealing with prior knowledge in an educational scenario the pedagogical concepts associated with this entity are tutorial, demonstration, presentation (Gagné, 1965), stimulating recall of prior learning (Robinson, 1998) self-awareness of knowledge construction, ownership of learning (Heinich et al., 2002), observation (Kolb, 1984) and relevance (Keller, 1983). These concepts can be mapped with the game design pattern reconnaissance (known areas in the game and detection of changes).

The pedagogical taxonomies mentioned comprise a very large spectrum of all kinds of learning activities fit for various domains and contexts. Limiting the focus on social interaction patterns may be rather ideal for domains where communication and collaboration are of critical importance. In a nutshell, the approach is meant to help an educational game designer find game patterns to build a game either from scratch or out of a non-game based learning scenario. In life-long learning, especially well designed games that follow a logical and structured lead, help to avoid irregularities that can quickly become frustrating.

Finding and choosing game patterns on their own is not always required, sometimes a course designer may instantly see options for introducing a game pattern to an existing activity, but browsing through the wealth of existing game patterns is likely to spark some creativity and help with future applications of the technique. Indeed the application of game patterns in innovative ways, and their utilization in contexts beyond their examples, and the documentation of such applications should be considered valuable input to the ongoing research of game patterns and their application in a learning context. Furthermore, a pattern-based approach helps to streamline the design process of a learning game from a software engineering point of view: conceptual patterns can be transformed into actual software modules more easily, while heeding important requirements like reusability and interoperability (Mor et al., 2006; Winters and Mor, 2009).

1.5. Trends

Since a few years, projects with relation to game based learning indicate that the approach is taken seriously not only scientifically, but also politically. At the EU level various projects have been completed, such as the ELEKTRA project (Elektra, 2009) and the 80 Days project (80 Days Project, 2009), as well as subinitiatives of various other EU projects on Technology Enhanced Learning. The approach yields discoveries to be made, not only due to the many variables to be accounted for research-wise, but also due to the fast-paced innovation development of the gaming sector as such.

New technologies continuously emerge, and the state of the art proves an exciting field to master and participate in. While our approach of systematic pattern based learning game design might seem somewhat schoolmasterly, it is noteworthy that the discovery and addition of new patterns or pattern structures is greatly welcomed, and will be of highest relevance to the research field, enabling a sound and up-to-date matching with current educational practices. It is also our own aim to continuously contribute new mappings between education and game design and experiment with those, which will be our focus in upcoming publications following this chapter.

New dimensions of gaming are introduced every year with advances in the video gaming industry. Recent interesting additions with greatly enhanced options for educational content development would be the significant advances in human interface technologies that are heralded by the arrival and popularity of the Nintendo Wii. With the advent of Microsoft's "Kinect"(Stenzel, 2011), all the major gaming consoles offer a level of motion interaction, of which Project Natal is currently the most advanced. Its capabilities of capturing a person's movements as a wireframe have the potential of enabling a whole host of new learning capabilities, for example learning activities that involve teaching movements and interactions, with minimal material costs or overhead.

Another aspect of learning games obviously comes with mobile and location based technologies, breaking with the prejudice of games being screen-locked. The most powerful 3D graphic engine is in fact the real world, which is available without programming effort. By augmenting the real world with mobile indicators, not only do we save time and effort in creation of learning games, but we also enhance the overall experience of the digital world. It was inconceivable only a few years ago that playing computer games actually could ever involve physical exercise, fresh air, sunshine and socializing; factors we find especially attractive for use in life-long learning scenarios.

Even though these new possibilities may be highly stimulating with respect to the spawning of new types of learning games, at the same time it is of interest to explore and keep track of which types of learning can best be supported by which mode of gaming. This is why the game pattern approach is important and needs to be constantly updated and extended, as well as continuously used for validation of "gaming/learning" hypotheses that emerge at the same pace as new game technologies.

1.6. Outlook

In this introductory chapter, we argued for the use of gaming patterns in life-long learning, which will be further explored in the upcoming chapters.

In chapter 2, we will first take a look at underlying theories and concepts that explain our fundamental assumptions about the use of game design patterns for learning by making use of an algorithmic concept that maps learning functions onto game design patterns.

In chapter 3 this view is complemented with additional design principles that originate from existing e-learning and game design standards and how these can be merged in order to enable the reuse of existing technologies and design methodologies. Here, a two-sided model will be introduced that enables to launch the design process from either side: learning or gaming.

Then, in part II, several experiments have been conducted and their reports are presented in order to substantiate the theoretical findings from part I. In fact we looked at different aspects of where game design patterns could enhance the learning outcome, i.e. awareness, engagement, motivation, knowledge gain, suspense, transfer and enjoyment. In order to cover these factors a set of different learning scenarios has been chosen for experimentation. First, in chapter 4 we present a small study that deals with informal social learning while making use of ubiquitous technology to support awareness.

Next, in chapter 5, an experiment has been carried out making use of a more traditional online-learning context and including two separate game design patterns combinatorially, in order to test the effects on learners.

This approach has been extended in further depth in chapter 6, including more powerful research methods.

Finally, in chapter 7, we altered conditions (learning context, representation of game elements) slightly, in order to cover remaining questions and to explore the limitations of our concepts.

All in all, the key criteria to judge on game-based enhancements are appreciation and learning outcome. By using a systematic approach, it can be traced which pattern – or which combination of patterns – have measurably positive effects: As we will see, a method which is likely to continuously improve the research society's understanding of why, how and when learning games work, or not.

Chapter 2.

Theories and main concept

Abstract: This chapter[1] concerns the design of digital games for learning (also often referred to as "serious games"). Although the potential of games for teaching and learning is undisputed, two main barriers hamper its wide introduction. First, the design of such games tends to be complex, laborious and costly. Second, the requirements for a sensible game do not necessarily coincide with the requirements for effective learning. To solve this problem, we propose a methodology to the design of learning games by using game design patterns and matching these with corresponding learning functions, which is expected to reduce design effort and help determining the right balance between game elements and learning. First empirical results indicate that such a methodology actually can work.

2.1. Introduction

In the design of educational games the main challenge is to find the right balance between the gaming and learning aspect. Games have in common the notion of interactivity, which creates a great immersive power, the capturing of attention, and thus have the potential for high motivation and flow experience. As Schell points out in his book on game design (Schell, 2008), designing successful games requires a very broad amount of different perspectives to consider. Although we limit ourselves here to the "learning game" design questions mostly targeting higher or vocational distance education contexts, a tremendous amount of complexity remains to be dealt with. An aspect that seems to get on top of this complexity is the recently quite popular term of "gamification", which denotes the practice

[1] This chapter is based on: Kelle, S., Klemke, R. and Specht, M. (2011). Design Patterns for Learning Games. International Journal of Technology Enhanced Learning, Vol 3 No. 6 (pp. 555-569) Geneva: Inderscience

of adding game functions and elements to an existing non-game-based activity or content. This adds a layer of "fun" to otherwise not very appealing tasks: Ludewig and Bager (2011) describe how mundane tasks like questionnaires or tidying up the email client can be "gamified". In our context of education and learning, similar problems arise, when students have to deal with notoriously "dry" content. At the current point of time, the term "gamification" is not yet included in dictionaries, but can be found increasingly when searching for it on the web. As Ludewig and Bager (2011) put it, gamification helps improve task- and workplace related issues, as well as enhancing social network functionality, but especially in educational context the issue still demands some underlying reasoning as well as suitable methods and components for gamification.

Our starting point for going into depth of this is exploring game design patterns and how they can be used for education. In fact, we will explore how game design patterns can be mapped onto educational methods and requirements, in order to facilitate learning game design. As a first step, in a literature review we will cover the most important existing resources to the topic of game-design patterns for learning, which are not very numerous so far. Also, we will aim at linking to notable works relevant for game-based learning on a more general scale. Then, a brief description of game design patterns is given and their combined use in game design. Furthermore, existing pedagogical frameworks are analysed in order to enable a mapping of game design patterns onto pedagogical strategies, and vice versa. Next, the mapping procedure is explained and carried out. The outcomes are presented and discussed. Finally, the concept of "game learning patterns" (GLP) is introduced and it is explained how these could be applied for enhancing education with game-based learning. In an interview with experts we established a first empirical step towards verification and reproducibility of this concept.

2.2. Literature Review

Game-based learning in the digital form has already existed for a long while, according to Garris et al. (2002) in two different main forms: as simulators and as motivators. What unites the two approaches is the fact that the gamer gets "hooked" in a series of triggered cognitive processes that have been proven to be beneficial for learning and create a high focus of attention, fostering the desirable experience of "flow". The terminology for the simulation kind of learning games is also known as serious gaming Susi et al. (2007), which denotes the concept of training for the serious application of knowledge in reality, while learners are not exposed to critical risks they might encounter in the real world (such as medical surgery simulations or pilot training).

The "motivator" kind of learning games (especially in higher and vocational education) rather aim at the self-governed type of learning where a positive learning experience is needed to overcome certain barriers like loss of attention, frustration with difficult to understand content, autogenous demotivation, and the absence of consistence and guidance in the learning process. As another classification of learning games, Susi et al. (2007) differentiate between Military games, Educational games, Corporate games and Healthcare games. We acknowledge that in more recent resources on serious games (e.g. Ritterfeld et al. (2009)), educational games are regarded as subclass of serious games.

In this chapter, we propose that (with focus on learning game for educational/motivator purpose) the use of game design patterns could be of help. In the literature we find also some evidence for this: a collection of about 200 game design patterns compiled by Björk and Holopainen (2004), which describe well-defined and well-delimited components composing a game. The use of game design patterns is a valuable contribution to reducing game design complexity and increasing design efficiency.

So far, some first indications can be found for game design pattern that work for learning contexts (Plass and Homer, 2009; Huynh-Kim-Bang et al., 2010). Although the approaches mentioned provide promising examples, it is still unclear how these game design patterns approaches are beneficial for the development of educational games, i.e. how the available patterns are linked with educational patterns, from the perspective of pedagogical methods and theories.

Malo et al. (2008) take another approach, describing the Rostock Model for E-learning (ROME) that they tried out for designing learning games. The ROME model describes a procedure for the systematic development of e-learning solutions, but as such was not very successful for the design of learning games. However, when they extended it by including "fascination elements" into the design, suddenly it began to work. These findings speak for the fact that learning games contain certain distinctive design elements that are responsible for a positive learning experience that is perceived by the learner as joyful game-like activity. Amplified by the successes of the video game industry, educational games have gained in volume and influence (De Freitas and Griffiths, 2008).

The inherent complexity of game design is a main barrier for their wider use in education (Westera et al., 2008). Indeed, the domain of games covers a great diversity of game genres and modes of play (Gredler, 1994, 2004; Rieber, 2005). This produces a greatly fragmented domain both from the perspective of design methodology and the underlying theories. Also, from the design perspective, complexity is hardly reduced by new technological advances which include social networking services in or around the game, the intertwinement of game consoles and the internet as a platform for multiplaying and exchange of content, and the emergence of powerful portable devices for end-users.

In educational frameworks and theories games are accepted to the extent that they often are regarded as a distinct educational method that does not quite conform to the existing paradigms (Smaldino et al., 2011). However, Learning Games can be classified due to their application context, such as target audience and domain. De Freitas (2006) review various frameworks that can help teachers evaluate the appropriateness of educational games and simulations for a particular learning context.

Kiili (2005, 2007) focuses on games for experiential learning and looks into the conditions that contribute to achieve experiential flow. Although the research of Kiili explicitly links educational theory with game design, it sincerely reports not to be able to address or improve game design.

The following two subsections will describe in more detail the design perspective from the gaming side, and vice-versa from the educational side.

2.3. Design Patterns for Gaming

According to Gamma (1995), a design pattern systematically names, motivates, and explains a general design that addresses a recurring design problem. It describes the problem, the solution, when to apply the solution, and its consequences. It also gives implementation hints and examples. Unlike software design patterns that are already touching upon the implementation itself by including reusable code fragments, we are dealing with "Alexandrian" style patterns (Alexander, 1976) that consist largely of textual descriptions that yield the following three main advantages (Agerbo and Cornils, 1998): encapsulation of experience, providing a common vocabulary and enhancement of documentation.

These advantages are of quite universal nature, and are (among other application contexts) relevant for game design, especially when dealing with the technical implementation. While addressing the intrinsic complexity of computer game design Björk and Holopainen (2004) developed a large inventory of design patterns particularly relevant for games. They proposed an activity-based framework of game design patterns based on the assumption that playing a game can be described as making changes in quantitative game states. By using four different views on games, i.e. holistic (describing the actual activities), boundaries (describing limits of these activities), temporal (describing temporal order of the gameplay) and structural view (the functionalities of a game and their interplay), they identified eleven main categories of game design patterns. These main categories are briefly explained in table 2.1 and form the entry point for the mapping procedure described in this approach.

Björk and Holopainen (2004) compiled a repository of over 200 game design patterns grouped in these categories. The different design patterns describe the building blocks of a game. An example structure of a game design pattern is displayed in figure 2.1.

Each pattern comprises the following components: a general description, information on how to use the pattern, some examples, a description of the consequences of its application, and, in some cases, structural information in terms of what other patterns are in conflict. A key characteristic of game design patterns is that they almost never appear alone. They need to be combined logically with other patterns in order to form a game structure. This is why a game design pattern structurally is defined by its interaction with other patterns. Each pattern may be linked with other pattern types through either instantiation (the presence of one pattern causes the presence of the other pattern) or modulation (one pattern influences the other pattern). This instantiation and modulation can be across different pattern categories.

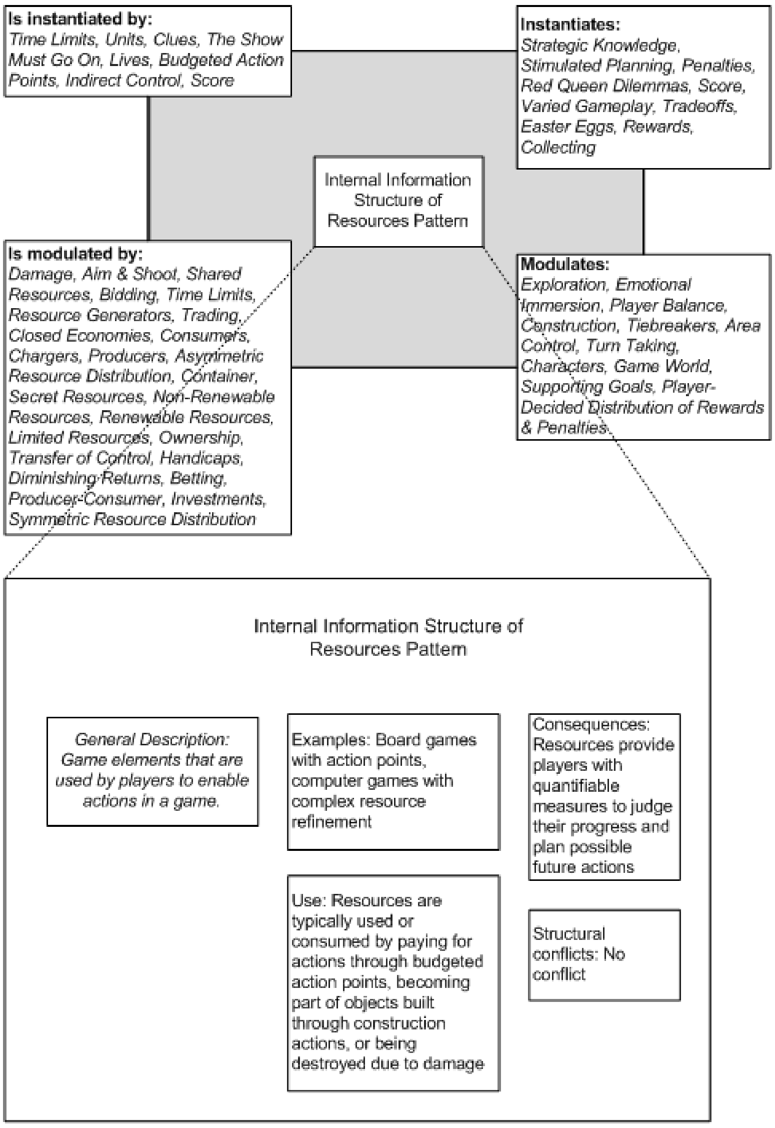

Figure 2.1.: Resources pattern.

Figure 2.1 displays a condensed version of the resources pattern, describing the budget, which supports the player's ability to fund actions. Also, the connections for instantiation and modulation with different patterns are indicated. At the more concrete level the resource pattern might be implemented as a "reward" pattern: the players receive something perceived as positive or are relieved from a negative effect.

The structural linkage between patterns is of predominant importance because the overall game structure depends on it. A simple example of an instantiation connection between patterns is this: *Status indicators* are instantiated by *score*. The instantiation implies that the presence of *score* is reflected as *status indicator* in the game.

As mentioned above, there are three constraints for linking patterns: instantiation, modulation and conflict. In each description of a pattern (see figure 2.1) all other patterns that can be linked are listed, as well as those that are in conflict. Each pattern thus has a "connectivity degree" that denotes the number of different patterns that can be linked to it, as well as a "conflict degree" that denotes the number of patterns logically in conflict. For example, the "real-time games" session pattern is in conflict with the "turn taking" event pattern. This is because the dynamic of a real-time game is not waiting for anyone to take turns.

Closely related to the instantiation linkage, game design patterns have an *emergent chaining property*, meaning that the use of one pattern automatically suggests (or even enforces) the presence of one or more other patterns.

Example. To stick with the "score" example, a football game could possibly be modelled by starting with the score pattern. Roughly, the score pattern's function in this case is that a team earns a point when hitting the opponent's goal with the ball. By describing this function we already used a couple of more patterns that are necessary to more specifically describe what is going on: Team, point, opponent, goal, ball. All of these are individual design patterns that in combination provide the level of detail required to describe game elements and rules. In connection with this observation, there is also a phenomenon that could be described as pattern containing patterns.

Example. Coming back to the football example, regarding rules and actions, this containment would describe individual tackling between two players, then on a more general level the competing of two teams (=football match), finally the local championship and ultimately the world championship (cf. figure 2.2).

Such a pattern containment illustrates how the patterns can be understood as building blocks for a game, which, if composed, form “whole” objects that can be treated as building blocks on the next abstraction level themselves. Structurally, it would be possible to combine blocks that reside on different levels of containment. The entity “football match”, for example, could theoretically be combined with a second ball, building a new kind of game.

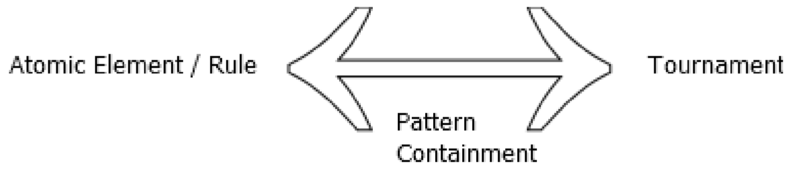

Figure 2.2.: Pattern containment

Finally, one of the emerging trends in learning games is related to mobile learning games that indeed are related ubiquitous models of computer-based learning. The mobile learning paradigm encourages learning that is personalized, authentic, and situated (Traxler, 2009). Environmentally based on this paradigm is the principle of ubiquitous learning. This concept rests upon the idea of ubiquitous computing (Weiser, 1991), offering mobility combined with pervasive computing functionality (Lyytinen and Yoo, 2002). These concepts are then orchestrated by instructional designs. Permanency, accessibility, immediacy, interactivity, situatedness, and adaptability have been identified as the main characteristics for information support in ubiquitous learning (Ogata and Yano, 2004). Learners need to navigate more efficiently through information and find the right information in any given context Koole (2009).

One essential aspect to implement this concept is to keep the learner continuously aware about the learning environment. Several types of awareness can be distinguished (Ogata, 2009): social, task, concept, workspace, knowledge, and context awareness. Utilizing these awareness types to feed information channels in the environment of the learner, which may adhere to the notion of ambience, hence contributing to a non-intrusive way of interaction, as suggested by the Ambient Information Channels (AICHE) model proposed by Specht (2009), as displayed in figure 2.3.

2.4. Pedagogical Patterns

Patterns in education are quite common. The Pedagogical Patterns Project (Project, 2010) has captured a choice of patterns, that are relevant to the application of certain pedagogical strategies that help supporting an educational scenario (a course). An example is the “early bird” pattern, which describes the method of teaching the most important topics first or as early as possible. The patterns described here have in common that they are applicable to a real-life course scenario.

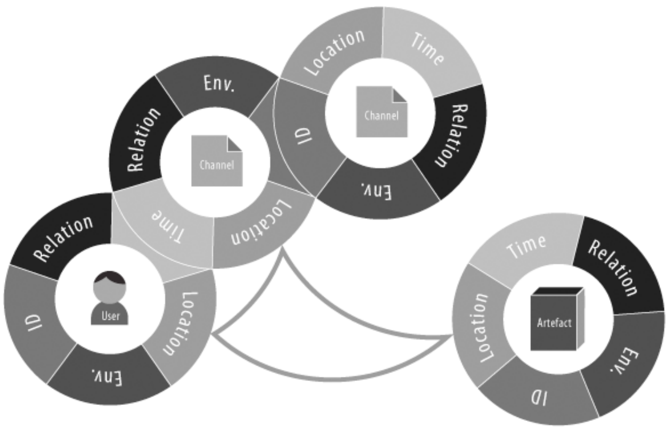

Figure 2.3.: The AICHE model (Specht, 2009): Ambient Information Channels for contextual learning support: The different channels are aggregated and serve as a framework between user and artifact.

A more generalist approach is described by Winters and Mor (2009) who collected educational patterns for the technology enhanced learning context from practical experience, and then generalized them. However, in order to be able to make the connection between games and learning using established pedagogical theories, we chose a different generalization model, by extending the scope of pedagogical patterns onto the taxonomy of learning functions.

Grösser (2007), referring to Shuell and Moran (1994), provides a decomposed list of 22 learning and teaching functions that are supposed to make up the pedagogical arena. These learning functions refer to cognitive and metacognitive activities that are provoked to improve the effectiveness and meaningfulness of learning, and they are all directly linked to instructional measures taken by teachers or education providers (see table 2.2). For reasons of convenience Shuell and Moran's functions have been regrouped according to different types of functions (preparation, knowledge manipulation, higher order relationships, learner regulation and productive actions, respectively).

Table 2.1.: Overview of game design pattern categories

	Pattern Category	Description
1	Game Elements Patterns	These patterns describe game objects that define the area of the game reality or that players can manipulate. (48 patterns) (for example: clues)
2	Patterns for Resources and Resource Management	These patterns describe different types of resources that can be controlled by the players and the game system. (20 patterns) (for example: resources)
3	Patterns for Information, Communication and Presentation	These patterns describe how information about the game state is treated, for instance hiding of specific information of for carrying out evaluations. (20 patterns) (for example: asymmetric information)
4	Actions and Events Patterns	These patterns govern what kinds of actions are available to players, how they relate to changes in the game state, and how they relate to the goals of the players. (44 patterns) (for example: rewards or penalties)
5	Patterns for Narrative Structures, Predictability and Immersion	These patterns deal with storyline, immersion and commitment to the game by the players. (31 patterns) (for example: surprises)
6	Patterns for social interaction	These patterns cover how games support social interaction between the players. (30 patterns) (for example: roleplaying)
7	Patterns for Goals	Goals give players objectives to aim for when playing games. (26 patterns) (example: gain information)
8	Patterns for Goal structures	These patterns describe how gameplay affects goals. (20 patterns) (example: tournaments)
9	Patterns for Game sessions	These patterns deal with the characteristics of game instances and game and play sessions and the limitations, possibilities, and features of player participation in the game. (20 patterns) (for example: time limits)
10	Patterns for game mastery and balancing	These patterns describe how the players can use their skills and abilities in playing the game and how it is possible to balance the gameplay for players with different abilities. (27 patterns) (for example: randomness)
11	Patterns for Meta Games Replayability and Learning Curves.	These patterns deal with issues that are outside the playing of a single game instance. (10 patterns) (for example: replayability)

Table 2.2.: Learning and teaching functions according to Shuell and Moran (1994)

Learning Functions	Teaching Functions
Preparation	
Prior Knowledge activation	Reminding students of prerequisite information or asking oneself what is already known about the topic being learned
Motivation	Learner persistence and contribution need to be nurtured
Expectation	Learners need to have a general idea of what is to be accomplished from the learning task. Providing an overview or the learner identifying the purpose of a lesson are ways in which expectations can be initiated
Attention	Enabling learners to focus on relevant information, disregarding the irrelevant information
Knowledge Manipulation	
Encoding	Assisting learners to add personal meaning to new information
Comparision	Making comparisons in searching for similarities and differences that permit the formation of higher-order relationships characteristic of understanding
Repetition	The inducement of multiple perspectives and engaging in systematic reviews are two ways in which this function can be initiated
Interpreting	Assisting learners in converting information from one form of representation to another
Exemplifying	Motivating learners to illustrate by making use of new examples
Higher Order Relationships	
Combination, integration, synthesis	Learners need to have a general idea of what is to be accomplished from the learning task. Providing an overview or the learner identifying the purpose of a lesson are ways in which expectations can be initiated.
Classifying	Enabling learners to determine categories of concepts
Summarizing	Guiding learners in writing short statements that represent information
Analysing	Guiding learners to break material into constituent parts and to determine how the parts are related
Learner Regulation	
Feedback	Learners need to interpret feedback on the adequacy and accuracy of their understanding
Evaluation	Providing learners with the opportunity to interpret and evaluate the feedback, as well as the opportunity to evaluate their own work against set criteria and standards
Monitoring	Providing learners with the opportunity to monitor their own learning progress, to determine if reason able progress is being made
Planning	Assisting learners in devising methods for accomplishing tasks
Productive Action	
Hypothesis generation	Encouraging learners to try alternate courses of action or generating alternative solutions
Inferring	Assisting learners to draw conclusions from presented information
Explaining	Guiding learners in constructing mentally and using cause and- effect models
Applying	Teaching learners how to utilise procedures to perform exercises or solve problems
Producing and constructing	Guiding learners to invent a product

The idea that game design patterns may be regarded as distinct pedagogical interventions is a strong point in case for a mapping of design patterns onto learning and teaching functions. Indeed, in learning games, the teacher's interventions are largely replaced with single or combined game patterns. However, Shuell and Moran's description does not entail why and when these interventions would be appropriate, that is, how the learning and teaching functions are related to existing pedagogical models and theories.

Therefore, as intermediate step, the most relevant educational taxonomies are portrayed below to establish the link between game patterns and learning functions. Very similar to the domain of gaming, pedagogy theory is known to be diverse and fragmented. Multiple perspectives are required for sufficiently describing it. In the following a selection of existing pedagogical taxonomies, which may be useful for linking with game design patterns, will be briefly explained. For this we start from the principal perspectives of any teaching and learning situation: pedagogical designs, instructional events, pedagogical goals, learning activities, learners' attitudes.

For each of these perspectives we selected the most prominent representative framework or taxonomy that features extensive research evidence and practical validity, that is widely accepted in the field: Heinich's pedagogical designs (Heinich et al., 2002), Gagné's instructional events (Gunter et al. (2006), originally Gagné (1965)), Robinson's pedagogical goals (Robinson, 1998), Kolb's learning activities (Kolb, 1984) and Keller's model for Attention, Relevance, Confidence and Satisfaction (ARCS) (Keller, 1983). Although these taxonomies are not exhaustive, their combined multiple perspectives may quite well represent the pedagogical aspects relevant for our context.

Below, a brief description of the approaches is given.

Heinich's pedagogical designs
Heinich et al. (2002) distinguish 10 basic patterns that are commonly considered in pedagogical design (cf. upper left box in figure 2.4). Note that gaming even is a separate category in Heinich's list. In principle, though, it should be possible to include Heinich's other instructional categories in a game design, for instance simulation, co-operative learning or drill-and-practice. Wang and Koohang (2008) clearly articulates the limited representativeness of Heinich's patterns by claiming that the use of information technology in education will bring up new instructional methods beyond this list.

Gagné's instructional events
The upper right box of figure 3 lists Gagné's 9 instructional events (Gunter et al. (2006), originally Gagné (1965)). These are not quite compatible with Heinich's list, since they start from a different dimension by describing subsequent steps in the teaching process rather than pedagogical approaches. These events are all considered necessary conditions for successful learning to occur.

Robinson's pedagogical goals
The lower left box lists Robinsons's taxonomy of pedagogical goals (Robinson, 1998). Since learning is often highly goal driven, goal definition is an important step in the design of any learning situation. It is also important to note that the pedagogical goals closely relate with cognitive factors such as abilities to reflect, transfer, apply, reproduce and sustaining a good level of motivation. Robinson's

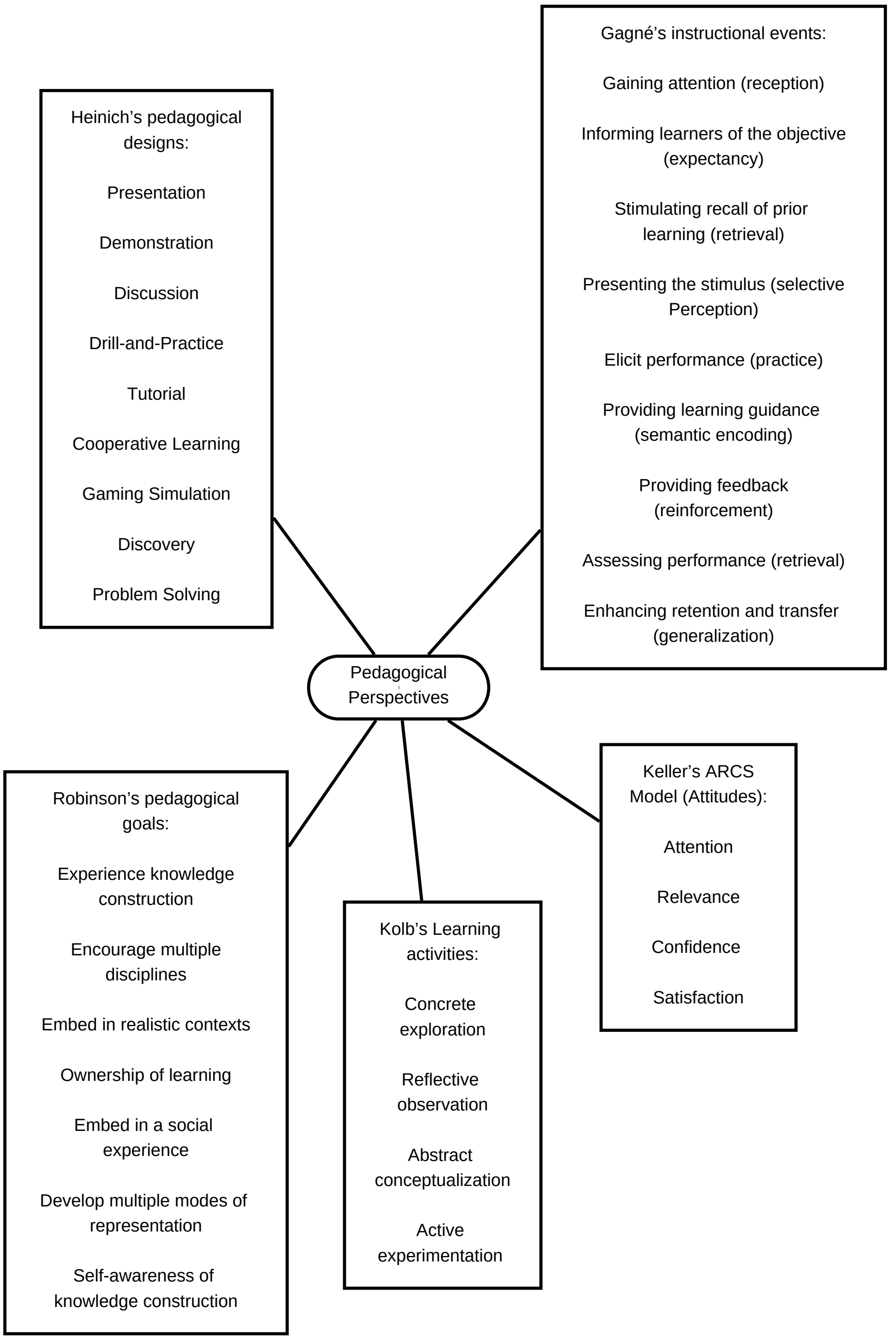

Figure 2.4.: Different pedagogical perspectives, organised in separate taxonomies

taxonomy is preferred here to the existing taxonomies of Bloom (1956) and Krathwohl (1964), because it more closely hints at practical implications.

Kolb's learning activities

The lower centred box lists the four main learning activities of Kolb's cycle of experiential learning (Kolb, 1984). Largely grounded on constructivism experiential learning is strongly linked with game-based learning. It is worth noting that playing a game can emphasize concrete exploration and active experimentation, at the expense of abstract conceptualisation and reflective observation. According to Kolb, all four steps in the cycle are essential for effective learning. This suggests that the transfer of games to education would require extra effort to include abstract conceptualisation and reflective observation. Similar considerations hold for theories of situated cognition and cognitive apprenticeship learning (Brown et al., 1989).

Keller's ARCS model
The lower right box contains Keller's ARCS model (Keller, 1983), which describes four steps of motivational design in instruction: Attention, Relevance, Confidence and Satisfaction. Keller's model is focused on the momentum of motivation as a crucial element in instructional methodologies. Motivation is an important condition for enhancing the learning experience, especially in game-based learning approaches. Capturing the attention of learners elicits expectations and readiness for what is to follow; inferring a notion of relevance raises this attention even further and makes the subject matter being taken serious; confidence is a key ingredient to sustain motivation, and satisfaction relates to the experience of reward upon meeting learning goals. Keller's model explains what to do to enhance motivation, but only on a fairly general level.

2.5. Mapping of Pedagogy on Game Design Patterns

As mentioned in the introduction, the notion of "gamification" as a means of transforming a learning process into a game, could already form a first step into the direction of creating learning games. Breuer and Bente (2010) mention a taxonomy that supports such an effort in terms of establishing certain axes along which a learning (or "serious") game needs to be spanned during its design: platform, subject matter, learning goals, learning principles, target audience, interaction modes, application area, controls/interfaces and common gaming labels (puzzle, quiz, etc.).

Going into the direction of combining games and learning, for instance, Garris et al. (2002) suggested a general descriptive model, which links both game play and learning. While game play is considered an on-going cycle of interactions with the game environment and feedbacks on the actions performed, in this model the connection with learning is made explicit through a regular debriefing process which connects the game experience with the outside world. Although Garris' model explicitly links gaming and pedagogy, its level of abstraction doesn't quite match the inclusion of game design patterns. Likewise, Bopp (2006) has extensively analyzed the issue of mapping game play with educational activities. He organized the overall game-based learning process into subsequent phases. However, while this approach gives clues about how to organize a learning game's instructional sequence, there is still the need for identifying what exact game elements are relevant for the corresponding learning activity.

With the main challenge being a correct mapping between pedagogical/learning functions and game design patterns, the considerations above advocate that a clear reasoning behind a mapping is possible. We have to acknowledge the fact that there is a dependence on oscillating factors like context, domain, scenario and type of learning game. It is therefore either necessary to freeze those variables and only look at a specific scenario in order to validate hypotheses of what combinations fit well, or to identify those game design patterns that are likely to form a mapping result with relevance to a universal application spectrum. To come up with a mapping that we can build on, the latter approach seems more sensible, making use of only those patterns that reside relatively high on the "containment" scale (i.e. abstraction level). These "universal" patterns can subsequently get instantiated into more detailed sub-patterns, which is a process directed by the emergent chaining effect (one pattern demands the existence of another, etc.). Additionally, as factor for the choice of patterns, a relatively high connectivity degree of patterns should be accounted for. That means, that there are patterns that can be connected to a certain number of other patterns via instantiation or modulation links. If there is a big number of such possible links, the connectivity degree is high. The connectivity is noted as the middle value of the triple behind each pattern in below mapping tables.

Based on these considerations, a mapping procedure has been carried out. The mapping heuristic works according to the following step-by-step scheme:

1. Shuell and Moran (1994) list learning and teaching functions (cf. table 2.2) that have been used to act as the starting point of this mapping.

2. As a next step, the underlying pedagogical mechanisms of each learning function are identified, while referring to the various pedagogical perspectives listed in section 2.4. The connection between Shuell and Moran's learning and teaching functions and the pedagogical models listed in section 2.4 was done by analyzing semantic overlap between those. This means that for each of the pedagogical perspectives the relevant vocabulary and subcategories of the taxonomy are included.

3. Subsequently, the associated pedagogical concepts for the respective learning approach are mapped onto game design patterns that have the potential to fulfill the pedagogical requirements in a general way.

4. The next step is to make the choice of game design pattern classes that are likely to support the pedagogical concepts relevant for each of the learning/teaching functions. As representative for a class, a concrete pattern may be chosen. While using the game design patterns inventory of Björk and Holopainen (2004), the names of patterns serve as primary semantic indicator for fulfilling this requirement. Also the verbal definition of each pattern, explaining the function of each pattern can be used for this. For example: the learning function of "repetition" semantically implies a recurring process in order to achieve "drill and practice", which from a gaming perspective requires the "replayability" pattern, enabling the possibility to repeat a certain game sequence.

Since the mapping procedure is not a plain algorithm but requires some interpretation by the assessor, we arranged a test for checking the procedure's reproducibility and validity. For this validation test, a sample of 11 game design patterns that are drawn from all the different classes of patterns (cf. table 2.1) was taken and presented to 10 experts of the topic (who are familiar with the pedagogical theories sketched in figure 2.4). After a brief explanation of the game pattern, each expert was asked to rate the pattern according to how well it might support each of Shuell and Moran's learning functions (Shuell and Moran, 1994).

To do so, the five-step procedure described above should be applied. For each of the learning functions the experts rated each of the patterns on a Likert-scale between 1 (least matching) and 5 (best matching).

The patterns chosen were: Score, Resources, Asymmetric Information, Surprises, Role-play, Gain Information, Randomness, Levels, Clues and Time Limits as representative and most prominent examples of categories found in educational games. Also, we needed to simplify the rating process with our experts. It is assumable that if a mapping between education and gaming is already possible with a relatively small pattern set, it can also be achieved with a larger collection of patterns to choose from.

The outcome of this ascertainment yields different perspectives: First, we looked at the patterns that were rated highest for being usable for application in the respective pedagogical scenarios. Calculated on average over all ratings and learning functions, the pattern of "gain information" scored highest with a score of 4.01 with a quite low standard deviation of 1.098. Other patterns that ranked similarly high were the "clues" and "levels" patterns. When looking at the scores of pattern per learning function, we found that 20 out of the 22 learning functions were matched with a game design pattern with a score of 4 or more. Turning this relation around, we observed that all of the game patterns had at least one mapping with a learning function that was rated with 4 or more. In order to check the consistency of our result, we conducted a one-way ANOVA to check where there were significant differences of means in the rating of patterns compared by the group variable "learning function".

The result was that the most significantly different ratings were done for the "score" pattern ($F = 4.701, p < 0.001$), the "asymmetric information" pattern: ($F = 2.115, p < 0.05$), the "time limit" pattern ($F = 1.886, p < 0.05$) and the "surprises" pattern ($F = 1.985, p < 0.05$). The other patterns were not rated significantly differently, i.e. most patterns were rated to match with different learning functions approximately equally bad or good. Relating to this, we looked for the level of agreement of the experts on their ratings, which were conceived independently: The outcome was measured employing the statistical method of intraclass correlation coefficient, calculated into a resulting Cronbach's Alpha value of 0.768, which can be interpreted as a fair level of agreement (different experts of the field mostly come to the same result). Combining these results, the described mapping procedure could be validated as reproducible.

2.6. Results

Encouraged by the results of the ascertainment described above, we applied the mapping method using the full set of 200 patterns, grouped into the eleven categories listed in table 2.1. The outcomes of the mapping procedure are presented below for each of the 22 learning functions.

The following notation is used: to each relevant design patterns, a number triple is assigned following the design pattern name, which denotes the category according to table 2.1, the connectivity degree and the conflict degree: "(category, connectivity degree, conflict degree)". For example the triple (1,19,3) behind the "clues" pattern in table 2.3, means that it belongs to the "game elements" category, has 19 patterns to which it could directly be linked, and it is in conflict with 3 patterns.

The following extra condition has been developed for selecting these patterns from the inventory: choosing a pattern with high connectivity degree and/or no conflict degree would present the designer with a large choice of patterns that can be linked to. However, choosing patterns that have a low connectivity degree but possibly a relatively high conflict degree, would limit the choice of other patterns to be linked. For quickly finding an indirect link between low degree patterns, a higher degree pattern (e.g. connectivity degree >20) can be more helpful, so the initial selection of patterns may profit from at least one of those patterns with high connectivity degree and/or low conflict degree.

A series of tables has been used, each of which covers a grouped selection of learning and teaching functions, conforming to the main categories of table 2.2.

The sequence of tables can be explained as follows: The first column represents learning and teaching functions the second column identifies the underlying pedagogical concepts, the third column shows the associated mapping to selected game design patterns (and classes).

Table 2.3.: Mapping of "Preparation" learning functions onto game design patterns

Learning Functions	Underlying taxonomy elements	Game Design Pattern (class)
Prior Knowledge Activation	Gagné's instructional event of "retrieval" (stimulating recall of prior learning).	Goals patterns, e.g. Reconnaissance (7,18,1)
Motivation	Chiefly, Keller's ARCS model is of relevance here.	Various patterns, mostly score related, for example rewards (4,54,1).
Attention	Both Keller and Gagné list Attention.	Game elements patterns, e.g. Surprises (5,30,16), Clues (1,19,3)
Expectation	Gagné's instructional event of "expectancy" (informing learners of the objective).	Goal related patterns, e.g. Predefined Goals (8,10,2), Narrative patterns e.g. Anticipation (5,22,2)

Table 2.4.: Mapping of "Knowledge Manipulation" learning functions onto game design patterns

Learning Functions	Underlying taxonomy elements	Game Design Pattern (class)
Encoding	Kolb's concept of Abstract Conceptualization	Information related game design patterns
Comparison	Kolb's concept of reflective observation	Information related game design patterns
Repetition	Heinich's design of drill and practice, Keller's concept of confidence	Meta game patterns, e.g. Replayability(11,23,8), and Randomness (as enabler for meaningful replayability)
Interpreting	Robinson's pedagogical goal of encouraging multiple perspectives	Goals patterns, e.g. Gain Information (7,21,1)

Table 2.5.: Mapping of "higher order relationships" learning functions onto game design patterns

Learning Functions	Underlying taxonomy elements	Game Design Pattern (class)
Combination, integration, synthesis	Robinson's pedagogical goal of gaining multiple perspectives.	Goals patterns, e.g. Gain Information (7,21,1)
Classifying	Keller's concept of relevance, Kolb's concept of conceptualization.	Information and Communication Patterns, e.g. Perfect Information (3,16,8)
Summarizing	Gagné's event of eliciting performance, Heinich's design of presentation.	Information and Communication Patterns, e.g. Communication channels (3,10,0), Patterns for game sessions, e.g. Time Limits (9,39,4)
Analysing	Heinich's design of problem solving	Patterns for game mastery and balance, e.g. Strategic Knowledge (10,48,1)

Table 2.6.: Mapping of "learner regulation" learning functions onto game design patterns

Learning Functions	Underlying taxonomy elements	Game Design Pattern (class)
Feedback	Gagné's event of providing feedback	Score related patterns, e.g. Score (4,18,0), Patterns for game mastery and balance, e.g. Near miss indicators (10,30,5), Information patterns, e.g. Progress indicators (3,21,2)
Evaluation	Keller's concept of relevance, Kolb's concept of conceptualization.	Information patterns, e.g. status indicators (3,14,2), Score related patterns, e.g. rewards (4,54,1) and penalties (4,51,3)
Monitoring	Gagné's event of providing learning guidance.	(same as for evaluation)
Planning	Kolb's concept of concrete exploration	Patterns for game mastery and balance, e.g. Stimulated Planning (10,51,0)

Table 2.7.: Mapping of "productive actions" learning functions onto game design patterns

Learning Functions	Underlying taxonomy elements	Game Design Pattern (class)
Hypothesis generation	Heinich's designs of discovery and problem solving.	Patterns for interaction, e.g. Exploration (6,33,1)
Inferring	Heinich's designs of discovery and problem solving.	Patterns for goal structures, e.g. Player defined Goals (8,27,2)
Explaining	Heinich's designs of presentation, demonstration and tutorial, Gagné's event of providing learning guidance	Patterns for information, e.g. Direct information (3,15,5), Game elements patterns, e.g. clues (1,19,3), helpers (1,10,1)
Applying	Kolb's concept of exploration and experimentation	Game elements patterns, e.g. Clues (1,19,3)
Producing and Constructing	Ownership of Learning, Kolb's concept of experimentation	Immersion patterns, e.g. Creative control (5,27,0)

As mentioned, the mapping of game design patterns has been systematized according to semantic overlap between learning functions, pedagogical perspectives and game design patterns. The central element to be able to do so is the pedagogical perspectives and taxonomies, allowing for a "translation" between learning function and game design pattern.

2.7. Introducing Game Learning Patterns

By producing a semantic mapping of educational functions onto game design patterns, the main conclusion of the work is that pedagogical key functions can be linked with game design patterns. By establishing this link it may now become possible to design learning functions (and thus courses and curricula in general) in a game-based way, or vice versa.

The main consequence of the mapping described is the genesis of "game learning patterns" (GLP). A GLP denotes a learning function supported by game design patterns. It reflects the pedagogical counterpart of a game design pattern. The formal description of such GLP can be based on those of game design patterns (figure 2.5).

A GLP would contain a general description of the pattern, which reveals its purpose and general characteristics, a description of the structure of combined game design patterns that make up the GLP, information about how to use the GLP,

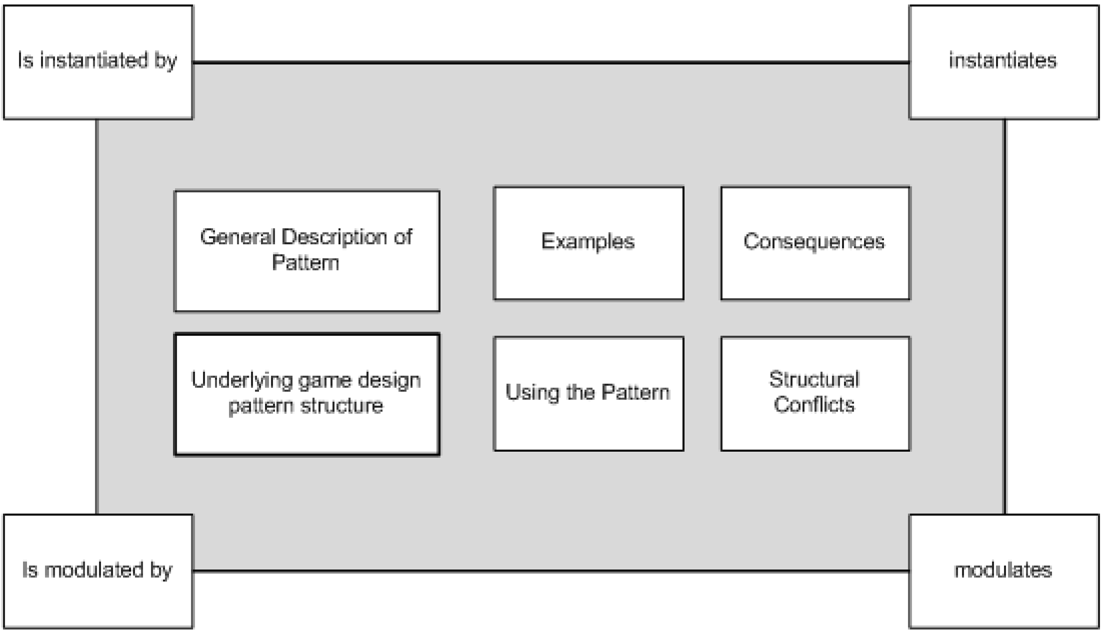

Figure 2.5.: The formal structure of a game learning pattern (GLP)

a description of the consequences of its application, some examples, and, in some cases, structural information in terms of what other GLPs are in conflict. Like common game design patterns, GLPs would be also defined by their interaction with other GLPs. Each pattern may be linked with other pattern types through either instantiation or modulation, as described in section 3. This instantiation and modulation can happen across different pattern categories. Various game learning patterns can be combined to form the overall learning game. With this in mind it becomes possible to either find game patterns that correspond to their pedagogical pendant directly, or to combine game patterns in such a way that they trigger, amplify, or altogether represent a certain pedagogical method.

In principle, four different approaches can be distinguished for the practical application of game design patterns (or GLPs) in education.

1. A first option would be the structured and pedagogically motivated design of serious games. So far, serious game design has been a complex and laborious. The present work signals new opportunities that come within reach. Game learning patterns may help amplify these developments.

2. A second option would be the enrichment of existing “COTS” (commercial off the shelf) games by means of game learning patterns (GLP) (Van Eck, 2006) to build a coherent pedagogical approach. Interestingly these additional patterns need not necessarily be integral part of the game logic itself. For example a game like ”Sim City” can be used for simulating urban devel-

opment, giving the learners insight on macroeconomic behavior of a society (Kuntz, 1999). While the game itself does not bear any kind of purposefully added learning function, the nature of the game play and game contents (building and managing a city) may provide sensible learning activities. Here GLPs can be used to extend the scope of the game and to achieve well considered guidance and support functions as well as appropriate integration within the existing learning context.

3. A third option would be the enhancement of existing education practice with game learning patterns. Indeed there is quite some research evidence that school lessons often fail to provide the challenging and motivation learning activities that would be required (Mac an Airchinnigh, 2010), especially for new generations of learners that have grown up immersed in a world of internet and video games. Here, GLPs may be made available in order to allow teachers to include game-like characteristics in their lessons.

4. Finally, for a sound integration of such GLPs within an existing educational setting it would also be necessary to develop methods and tools for identifying hidden pedagogical patterns or even hidden game patterns in existing educational practice. Indeed, certain game design patterns may quite likely be abundantly available in existing educational practice, for instance competition (grades), collaboration (group work), quizzes (tests) and many more.

2.8. Conclusion and Future Vision

This article has explained how game design patterns can be linked with educational functions. It has given a detailed elaboration of a mapping between the two domains and thus has opened up the perspective of pedagogically grounded and well-structured learning game design. The main outcome of this approach is that it was possible to form a mapping between classes of game-design patterns and learning functions, which gives suggestions when a learning game designer is faced with the question: *Which game elements might I add so my learning game works for my learning purpose?*

As a future direction for research the suggested approach gives a clear taxonomy for validation of the effectiveness of game design patterns / learning functions that are linked together via theoretically grounded taxonomies of pedagogy. The construct of "GLPs" helps solidifying these findings and making them reusable. Also, using patterns, it becomes possible to identify hidden game design patterns within the educational context, or reversely, it becomes possible to purposefully design learning functions composed of game elements. Combining all this, the "gamified" approach may become a dominating model for teaching and learning.

Chapter 3.

Standardization of Game-based Learning

Abstract: Standardization of design of learning games is a contradictory topic: The existence of a rich variety of domains and applications is in conflict with the desire for unification that would result in improved reusability, interoperability and reduction of design complexity. In this chapter[1], we describe the use of the ICOPER Reference Model (IRM) specification as foundation layer for the design of digital learning games. This reference model incorporates design and development processes as well as standards such as IMS Learning Design, a framework for presenting content according to logical rules like conditions and properties. The chapter reports about exemplary learning games that make use of e-learning standards the IRM consists of, and explains about potential and limitations both from the game and e-learning design perspective, resulting in suggestions how to close missing links.

3.1. Introduction

Ever since the advent of e-learning, various working groups, committees and bodies have been working on achieving standards and specifications for enhancing quality, interoperability and the reuse of learning contents and designs. Examples for such standardization bodies are CEN, IEEE, ISO, ADL, ANSI, DIN, BSI, and NEN, only to name a few (Sloep, 2002). One of the realities of different standardization bodies creating different standards can be a lot of overhead in coordination.

[1]This chapter is based on: Kelle, S., Klemke, R., Gruber, M., and Specht, M. (2011). Standardization of Game Based Learning Design. In B. Murgante, O. Gervasi, A. Iglesias, D. Taniar, & B. O. Apduphan (Eds.), Computational Science and Its Applications - ICCSA 2011 (pp. 518-532). LNCS 6785 Berlin, Heidelberg & New York: Springer.

Duval (2004) reports that as a consequence of this, one of the key problems in e-learning standardization is the lack of experimental validation of the actual usefulness especially of interoperability standards: They are theoretical constructs that are often of premature value, when it comes to practical application. However, there is still a high interest in common standards, amplified by the fact that large parts of the e-learning market are covered by schools and universities that generally support the exchange and sharing of knowledge across institutional or cultural barriers.

Inspired by the successes of the video gaming industry, as well as a trend in pedagogy, e-learning providers are increasingly incorporating game-based learning approaches. Due to the gaming industry taking the role as technology innovator for learning game incentives, relevant standards are often of a proprietary nature and closely tied to particular pieces of hardware, e.g. game consoles and game controllers. As a consequence of these marketing strategies that seek to preserve unique selling points, digital learning games go with a diversity of formats and file types, involving many different sub-standards relating to technology, content, and subcategories thereof. Nevertheless, similar to other e-learning formats, a digital learning game requires learning goals, learning contents, trajectories through the learning contents, and a structural framework that ties together all these components.

Therefore, it seems plausible that game-based learning could benefit from existing work on e-learning standards. In this chapter we will explore how e-learning standards could play a role in aligning the different elements that make up a digital learning game. We will analyze a recently developed reference model (the so-called ICOPER Reference Model) that was created from best practice experiences in e-learning for its potential to be used as conceptual framework for the design of learning games.

3.2. Problem Analysis

Various standards exist in the fields of e-learning and game design, however, little work has been done to connect both fields. With respect to the e-learning part of our scope, recently a big effort has been undertaken to find a coherent model that unites technical and conceptual standards available for the design of technology enhanced learning solutions: The ICOPER Reference Model (Simon and Pulkkinen, 2010). In this problem analysis, we will first describe the current situation of learning- and game design standards that are most relevant for interoperability, reusability and reduction of design complexity. Then we will cover the combined perspective of learning game design and point out some problematic aspects that result from the lack of bilateral standards.

3.2.1. Standards in Game Design

In digital gaming, technical standards have a high relevance that even can be of reciprocal character because many commercial games take the innovation role for technology, spearheading the latest developments and “setting” new standards at a fast pace. These modern technology standards encompass multimedia technologies for input, audio and (3D) graphics and are manifested as “game engines” that serve as mostly proprietary production models in professional game design and development. Examples are the DirectX standard (DirectX, 2012), Microsoft XNA (XNA, 2012) for developing Xbox console games, the “Vision Game Engine” (Vision, 2012) for developing multi-platform games, and as final example the CryEngine (Cryengine3, 2012) for developing videogames with the highest cinematic realism of what is possible today. These standards are technical standards, rather than design standards, but in gaming it is often difficult to differentiate between the design and implementation, therefore these “engines” come with documentation on how to design and develop games for them.

Modern digital games increasingly tend to make use of network features and provide added functionality by connecting to the internet, which requires the inclusion of a stack of telecommunication standards in the implementation. Already in 1984, Crawford (1984) mentioned the possible “connection of computer games over phone lines” as distinctive advantage of computer games over classic games. In his design methodology for computer games he describes a sequence that ranges through the initial choice of goal and topic, a preparation phase in which some research and brainstorming is needed, a structural design phase that has to be evaluated (falling back on the previous phase iteratively), and finally a programming, testing and post mortem phase. The reason for the long-lasting acceptance is that this design method resembles the most widely used software engineering models and has definitions that are sufficiently wide to leave interpretation space for the application on many different types of games. Although the creation of games relies on technical and structured software engineering methodologies, the creative aspect of the design process appears mystifying: according to Adams (2009), the idea creation at the early stage of the game design process is more an artistic than an engineering process.

Salen and Zimmerman (2003) have compiled a detailed description of important factors to consider for meaningful game design. They promote a systemic approach that frames a game inside a formal, experiential and cultural system that ranges from closed to open. In their compendium, one of the core elements of game design is the definition of game rules, which create the “game system” structurally. Rules of a game are categorized according to “constitutive”, “operational” and ”implicit” rules, which can be interpreted corresponding to a scale from “prescriptive” to “own choice”. Also the game play as such is equally important, as it is forming the experiential parts of the system. According to Salen and Zimmerman,“a game designer only indirectly designs the player's experience, by directly designing the rules". (p. 327).

An example for a game approach that makes use of "implicit" or "own choice" rules is interactive story-telling, which is found in many (especially adventure-) games. Due to the experiential nature of such games it is an approach that is often found in learning games. One of the concrete examples for such an approach has existed in a niche until the eighties, and only had some publicity in more recent times: Interactive Fiction. As described, for example, by Donikian and Portugal (2004), this medium abolishes the difference between author, spectator, actor and character, and creates a big potential for immersion, due to identification with a role and ownership of influence on a non-linear story sequence. The technology supporting this has been evolving for decades from simplistic single-user text adventure approaches up until now where there are authoring systems, for example Inform7 (2012) that understand natural language. The output files are usually in a system independent package format called "BLORB" (Blorb, 2012), which is interpretable by web-based engines (e.g. Glulx) that boast the power to render a fully-fledged multi-user adventure game to be played in a browser (Nelson, 2011).

Another, more general effort of standardizing game design can be found in the use of game design patterns, which preserve knowledge about building elements of games and give information on how to implement them. The approach is described semi-formally by Kreimeier (2002) who uses "Alexandrian" proxy patterns consisting of a problem description the pattern is going to deal with, a solution description, consequence description and examples. As mentioned in the previous chapter, Björk and Holopainen (2004) collected a large fundus of game design patterns, which extends the relatively informal approach of Kreimeier onto a more detailed and complete level. This approach is also endorsed by Westera et al. (2008) who stress the usefulness of patterns with respect to the reduction of design complexity.

3.2.2. Standards in E-Learning Design, united in the ICOPER Reference model

With respect to e-learning, Cooper and Kraan (2012) point out that standards in e-learning are important because they can avoid that information gets "locked into a supplier's product", and are able to join up different systems because they use the same data backend. While this is particular relevant for interoperability, standardization in e-learning also yields other desirable outcomes, like reusability and reduction of design complexity. In e-learning there are big efforts to create standards that make learning content transferable between technical platforms and educational scenarios. The ICOPER project, funded by the European E-Content-Plus program, reflects such a standardization effort on a meta-level, analyzing different standards on different levels and their interoperability. At the core of the project resides the ICOPER Reference Model (IRM) (Simon and Pulkkinen, 2010) that is based on a rich pool of best practice examples for the successful use of each substandard that concerns technology enhanced learning. It embraces all relevant standards available including content related standards, user modeling standards, interoperability standards as well as process oriented standards. The IRM, in its purpose to agglomerate various e-learning standards into a functional concept, shows promising directions, because it helps avoid the hazard of using standards that overlap and cause redundancies, as well as conflicting standards. In this paper the ICOPER Reference Model is chosen as the starting point of the analysis.

Table 3.1.: The e-learning standards used in the IRM

Standard	Description
RCD / LOD	Reusable Competency Definitions / ICOPER Learning Outcome Definition (LOD): LOD is an application profile based on RCD, a data model that captures key characteristics of desired learning outcomes by using metadata
PALO	Personal Achieved Learning Outcome profiles
LOM	Learning Object Metadata, a standard to describe metadata for learning objects
OAI-PMH	Open Archive Initiative's Protocol for Metadata Harvesting, a protocol specifying the harvesting of metadata of learning objects in repositories
IMS-LD	IMS Learning Design, a standard for sequencing content according to logical (e.g. adaptive) rules, as well as user roles
IMS-QTI	Question & Test Interoperability format, defining a data format for online assessments

With the help of these standards the main components of the IRM are formulated:

- The Domain Model
- Process Models
- Service Descriptions

- Data Schemes

The domain model consists of high-level learning context scenarios, which are drawn from institutional, corporate, professional and re-skilling training practices. The domain model is developed around key concepts such as learning outcome, learning design (including teaching method), learning content, learning opportunities and assessment.

These need to be matched for the respective purpose of each learning scenario and therefore are more of exemplary value. The domain model thus becomes a context-based scaffolding for designing the necessary processes and entities defined in the IRM so that they fit the domain or context.

Also, the IRM covers instances of process models serving learners, learning facilitators, and other stakeholders in the delivery of outcome-oriented teaching. In addition, the IRM contains service descriptions for search and retrieval, publication services, user management services, recommendation services, harvesting services, registry services, and validation services. Finally, data schemes are given for providing the relevant technological frameworks for storing dynamic data, schemas for personal achieved learning outcomes (PALO) and learning designs to be included on the backend side (Najjar et al., 2010). The data model of the IRM was prototypically implemented by the ICOPER project in the Open ICOPER Content Space (OICS); it covers a recommendation how to create a competence map for learning outcomes, an incremental model for different layers to create learning processes, a concept model, a domain model and, finally, a process iteration model on how to design IRM based solutions.

3.2.3. Standardization in Game-Based Learning Design

For making digital games that work for learning purposes, both aspects of gaming and learning and the standards relevant to them have to be combined. According to Ebner and Holzinger (2007), there are important advantages in standardization of technology such as compatibility, transferability and reusability. Also, there are advantages like social benefits, enabling standardized jargon to efficiently communicate among specialists of a specific subject. Disadvantages can be found mentioned in reduction of variety, retard of innovation as well as “excess inertia”, which Farrell and Saloner (1985) describes as the impediment of “switching from one standard or technology to a possibly superior standard or technology”.

One of the key reasons for dealing with standardization is that the creation of learning games is a very costly enterprise, as reported for example by Van Eck (2006) and Moreno-Ger et al. (2008). Each time a learning game is developed it requires a hand-tailored design and implementation from scratch. As possible solution to the problem they discuss the repurposing of commercial “off the shelf” (COTS) games for learning. Although such repurposing is easier said than done, it can save a lot of design and implementation effort. A concrete example is described by Gee et al. (2010) in which the role-playing game “The Sims” is adapted for collaborative learning purposes.

Still, the use of standardization in game-based learning has controversial aspects. Besides the possible hazard of reducing variety, Squire (2005) points out that in the information age certain fundamental principles of economic reality have changed since the dusk of industrial age: Conformity has been replaced with diversity, compliance with initiative and standardization with customization. Therefore, standardization may come at the cost of customization and other advantages that are related to flexibility of design methods, content, user interaction and other factors. This also has consequences for gaming: The reduction of flexibility might reduce motivation, fun and the possibility for immersion in game play, which is fundamental to the success of a game. On the other hand, standardization can also lead to innovation by lowering interoperability costs.

Relating more specifically to the topic of game-based learning, however, the situation of standardization is more on a taxonomical level. The Serious Games Initiative (Serious Games Initiative, 2012) have made the effort to pool together a taxonomy for serious games, in which a wide scope of different categories are listed. Unfortunately, this does not include any technical standards or recommendations on how to design or implement serious games.

Using a classification taxonomy is nevertheless a starting point to get an overview what different types of serious games exist and what are examples. According to Breuer and Bente serious games can be classified according to platform, subject matter, learning goals, learning principles, target audience, interaction modes, application area, controls/interfaces and common gaming labels (puzzle, quiz, etc.). This can help to inspire a learning-game designer to consider all options during the early stages of the design process.

The situation of standardization in learning games seems not very systematically developed but that does not mean that there are no working examples. When it comes to the implementation of a digital learning game, as reported by Livingstone and Hollins (2010), various technical standards for gaming can be put to use, such as different standards in 3D technologies (for instance, VRML, X3D, COLLADA, OpenGL and WebGL), browser languages and also different kinds of multimedia standards like flash or, more lately, HTML5, for example for the use in mobile devices.

Interactive storytelling has a specific relevance to the design of learning games, and the IMS-LD standard has been shown to have this potential (Richards, 2005). This can be done by creating conditions that rely on an extended propositional logic control (also known as IMS-LD Level B) which fire upon certain user behavior. For example: if the user behaves in a certain way, the system may detect that and react adaptively by rearranging the sequence of content. For example, Gruber et al. (2010) describe how IMS-LD is used successfully to present an interactive course on architecture, making use of such adaptive content sequencing. This enables a certain degree of “free movement” of a learner inside a coherent structure, which incorporates the challenge to solve a quest in order to advance on different paths through the learning content. In line with the principle of Open Information Access, this "free movement" can be interpreted as educational pattern that can be found in adaptive storytelling, as well as constructivist learning. Likewise, the IMS QTI specification (a specification for assessment of learning) would allow for quiz-like approaches of game-based learning (Grant, 2002).

This demonstrates that e-learning standards for adaptiveness and assessment have a potential to enrich game designs with functionality that is relevant for learning. In the concrete example of IMS-LD used here with the "Recourse" authoring tool, however, some limitations were detected, for example that in practical application repeating a certain activity was not possible, once a "unit of learning" had started (Gruber et al., 2010).

While this is a concrete example of a learning standard that does not quite live up to its theoretical power, on a more general note, in the design process the initial choice of one of the available standards is highly speculative, and there is no sound argumentation to know up-front which e-learning standard is appropriate for what learning game purpose. There may be some flexibility in choice, but not every e-learning standard is going to be of equal usefulness to the design of learning games, due to different requirements. To tackle this we need a more refined approach that helps to streamline design routines without omitting to consider important standardization methods.

3.3. Using the ICOPER Reference Model as bridge between gaming and learning

The fundamental assumption in this chapter is that parts of the ICOPER Reference Model can be used to build the bridge between gaming and learning. One of the key questions about building this bridge, is how the existing ICOPER Reference Model can be exploited for use in game-based learning design, where are possible gaps, and resulting thereof, how the existing IRM can be extended.

In addition to an overview of the status quo on existing approaches we found evidence about (i.e. learning games that use e-learning standards that appear in the IRM), we also will report about our own experiences and what we could learn from them. Finally, we will give recommendations on how to use the IRM for the design of learning games.

3.3.1. E-learning standards applied in games

In this section, we will shortly revisit the literature on existing learning games that have been using e-learning standards. As mentioned above, there are only few examples of learning games that make use of e-learning standards. The way IMS-LD theoretically works for the use in adaptive game-based units of learning is described by Burgos et al. (2007). They explain how the Level A and B of IMS-LD can be mainly used for creating the adaptivity of content presentation: Level A consists of user-modeling (users, roles) and content related components (environments, resources, links, activities). Level B consists of logical properties, conditions, calculations, global control elements and monitoring services. The architecture that enables the game-based learning approach relies on a proxy layer for communication between "game activities" (gamelets that correspond to interactive content elements) and the learning flow.

As a practical example, of this approach Moreno-Ger et al. (2007) have created an adaptive game using IMS-LD as control framework for a video game on chocolate making. In this example, the SLED-player environment (a tomcat-based web server module that interprets the XML-based units of learning that are the output of IMS-LD based authoring tools) works as an aggregator for the game content, while providing logical properties and conditions that steer the sequence of the game content, as well as user roles. It is, therefore, an example for the learning process controlling and triggering gaming elements.

For use in a virtual world environment, Livingstone and Hollins (2010) explain how interoperability can be achieved between learning management systems (LMS) and Second Life, a massively multiplayer online role play game that had its zenith in 2007, which remains of interest for experimental use of 3D game learning environment research. The design here consists mainly of a proxy layer between Moodle and the virtual world, which enables communication by means of http requests and XML-RPC calls[2], thus providing the linkage between dynamic objects in the virtual world and the LMS. Since most of the interaction happens inside the "game" world, this is an example for the gaming side taking control over the learning process; however, the communication layer puts the two aspects in balance and enables activities in both directions.

Another approach by Minović et al. (2009, 2010) describes the use of a meta-model for educational games (called the "educational game meta-model") that is based on knowledge modeling theory. The proposed model makes use of a series of information channels that enable communication between Knowledge Objects (interpreted here as Learning Objects) and the actual game components. On the implementation level, the approach is realized as XSLT-based web client, providing in this example a game-authoring environment and game client presenting an online adventure game in the domain of geography. Despite the promising direction

[2] http requests get the content from a web server and then execute dynamic functions locally, while XML-RPC calls send instructions that are executed on a web server.

of using open technical standards for creating the meta-model as layer between learning objects and functional game parts, the system is closed in itself, and the aspect of reusable content is missing. Since both authoring and gameplay happens within the "game" prototype, the learning flow is influenced and controlled by the game component.

Del Blanco et al. (2010a) use a virtual learning environment game, based on SCORM, forming a connection to a Moodle LMS in the background. Similar to the approach described by Livingstone and Hollins (2010), the game aspect takes the role of steering the occurrence of learning objects. In another approach by Del Blanco et al. (2010b), the LAMS Learning Activity Management System environment (LAMS, 2011) was used, encapsulating video gamelets in a quasi-IMS-LD logic, here the "IMS-LD" part was enabling that the LMS took over the sequencing of the game-based content.

Also, Börner (2007) describes a Flash based learning game that makes use of the SCORM standard to structure the learning content of the game. For multi-user aspects, a distributed server architecture was used. The design is strongly dependent of the overall learning trajectory; therefore, in this case the learning process takes control over the game sequence.

3.3.2. Experiences

Schmitz et al. (2011) report on the design of the SPITKOM's "Bauboss" learning game using e-learning standards that are found in the ICOPER Reference Model (IRM) (Simon and Pulkkinen, 2010).

The SPITKOM project drives at a game-based learning approach to train for the European Computer Driver's License ECDL (ECDL, 2011), by means of addressing construction workers with a familiar look and feel. It forms an example, how the IRM is used as "slave-standard". The main process is driven by hard-coded game logic which uses the learning outcomes, learning contents, assessments and personal achievement profiles that are explicitly modeled and stored in the Open ICOPER Content Space (OICS). Reusability in SPITKOM can thus be achieved mainly on the level of learning content, thus it would be straightforward to reuse the approach in a different content domain (by exchanging the domain model). However, since the game-logic is hard-coded, it would be difficult to create reuse with a different game-logic – the game component would have to be exchanged with a new one.

Another approach is using the IRM as "master-standard", making use primarily of IMS-LD to design the structure. An adaptive learning game on a quiz-like basis was developed for the training of first aid and basic life support. The basic procedure was, similar to the approach described in Burgos et al. (2007) and Mor et al. (2006), to use IMS-LD Level B for creating the control structure of the adaptive

Figure 3.1.: The game "Bauboss", created in the SPITKOM project

story-telling used in the game. In this case, the domain model was fixed, but the control structure could be easily adapted. For practical reasons the implementation of the game-based learning design we used the Emergo toolkit Nadolski et al. (2008) that provides a similar expressiveness as IMS-LD and the same range of functionality we were interested in. A screenshot is presented in figure 3.2.

The resulting prototype was used for performing experiments on the effects of different game design patterns on learning.

These practical examples allow for a comparison. While the SPITKOM approach seemed to satisfy the preferences of gamers, the missing part was the explicit teaching method and the corresponding learning design. This was done for the benefit of a specialized and more game-like user interface. It demonstrates that the requirement of a challenging game experience conflicts with the pedagogical requirements because there was little flexibility regarding modification requests.

In this area the IMS-LD based approach was more flexible, because there, both content and game logic (the logic that is in place to determine the user feedback and the game progress/outcome) can quickly be altered according to changing learning outcome definitions or learner profiles. Another advantage is that IMS-LD has the potential to use external learning material and, hence, be linked with the service architecture provided by the OICS.

However, e-learning driven examples for the design of game-based learning could have the disadvantage to disappoint learners that expect a fully-fledged gaming experience, because they adhere to e-learning standards from the beginning, resulting in a shortcoming on the game-like behavior and feeling of the result.

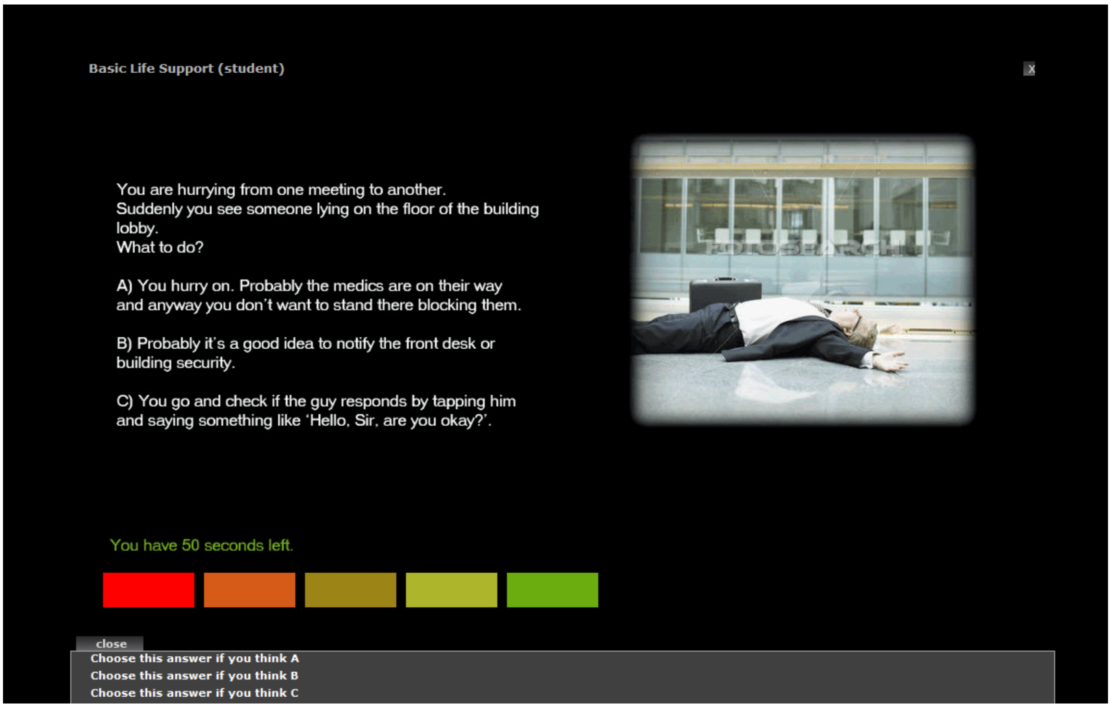

Figure 3.2.: The Basic Life Support training game, using EMERGO game platform

This leads us to a missing link between game standards and learning standards.

3.3.3. Duality between Gaming and the e-learning design

The two different approaches reflect different design methodologies (start the design cycle from the gaming or the e-learning standards perspective). These approaches match with what we have been trying in practice. Starting the design from the side of learning, it is possible to model the educational process and then iteratively integrate game elements into the instructional design. Starting from the game perspective, the methodology links game elements with learning activities and outcomes instead.

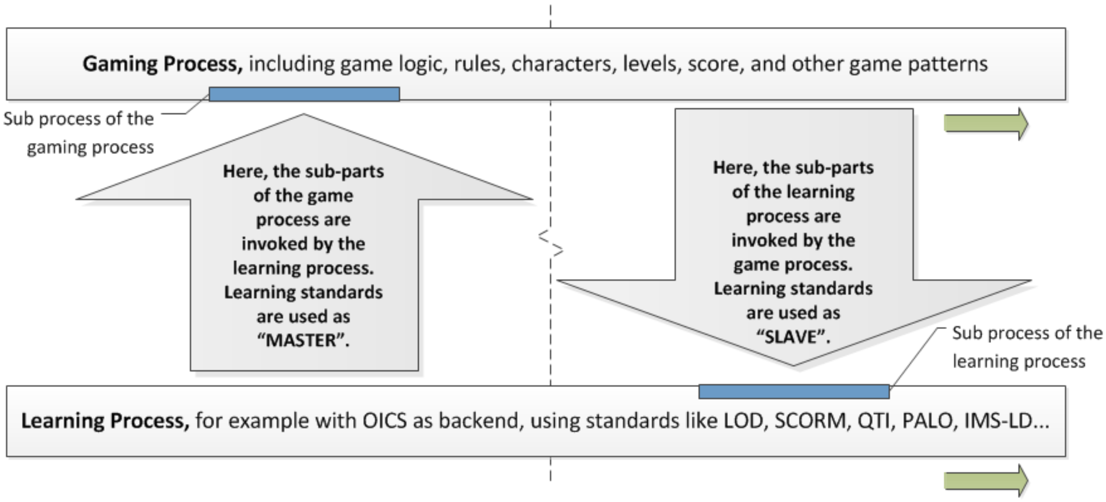

Figure 3.3.: The "Master" usage of e-learning standards is applied in the Basic Life Support game prototype, while SPITKOM uses the e-learning standards as "Slave" model (in this case: the OICS). The ideal situation would be to have both directions in one learning game.

The result of the two different approaches, i.e. using e-learning standards as "master" and "slave" model (figure 3.3), proved two main disadvantages. In the case of the SPITKOM game, the problem is that the game component is difficult to adapt and hence provides difficulties for reusability. Also the IRM/OICS needs to "satisfy" the game requirements, which poses the encounter of rigidness with respect to interoperability questions.

The other approach, i.e. using e-learning standards to start out from, poses the repurposing of e-learning based frameworks for gaming, which turned out to have limitations with the respect to making a learning game that actually has the properties and "feel" of a real game.

In table 3.2 we summarize how the described approaches make use of e-learning standards. This is concluded by the way the design approach is described in the corresponding literature, starting out by first designing the game component or

Table 3.2.: How the discussed games make use of e-learning standards

Approach	Makes use of what e-learning standard	Corresponds to the use of learning standards as	Remarks
Moreno-Ger's Game	IMS-LD	"master"	
Livingstone and Hollins' 3D game concept	SCORM	"slave"	work in progress
Minović's game	Learning Objects	"slave"	
Börner's game	SCORM	"master"	
del Blanco's e-adventure games,	SCORM , IMS-LD	"slave" , "master"	The game design was done in IMS-LD but the implementation was using LAMS.
SPITKOM game	LOD, SCORM and QTI	"slave"	

starting the design with consideration of e-learning standards, as described in 3.3.1. It becomes visible that the list of learning games that use IRM-conform e-learning standards is indeed quite short. This indicates there is still a large gap between e-learning standards and learning game design.

3.4. Discussion

Although there has been proof-of-concept for different applications making use of Learning Objects, SCORM and IMS-LD for game-based learning, a more holistic design approach is desirable, especially when considering the full spectrum the IRM offers with respect to meeting requirements for learning. As a possibility, the Game and Learning aspect could be serialized in the design process, where a first idea and draft concept of a learning game is followed by the formalization of a domain model, which serves as construction scaffold and requirement specification for the remaining parts.

One suggestion is that the definition of game rules could be complemented with learning outcome definitions (LOD) on the learning side as well as control structures defined in IMS-LD.

Correspondingly, the design of game play (as a consequence of the game rules) on the learning side are matched with teaching methods and learning design is reflected in adaptive content modules (e.g. SCORM). Scoring may be realized with assessment (QTI) elements.

Finally, the technical requirements engineering as well as implementation of the game design are reflected on the learning side with the content repository Open ICOPER Content Space (OICS), which forms a backend, provisioning content and metadata to fill external learning services with learning material. In addition it offers an assessment infrastructure and user modeling framework, making it a backend for learning management systems; and all the elements mentioned before as being relevant to the design process of learning games (LOD, PALO, QTI, etc.) are stored here.

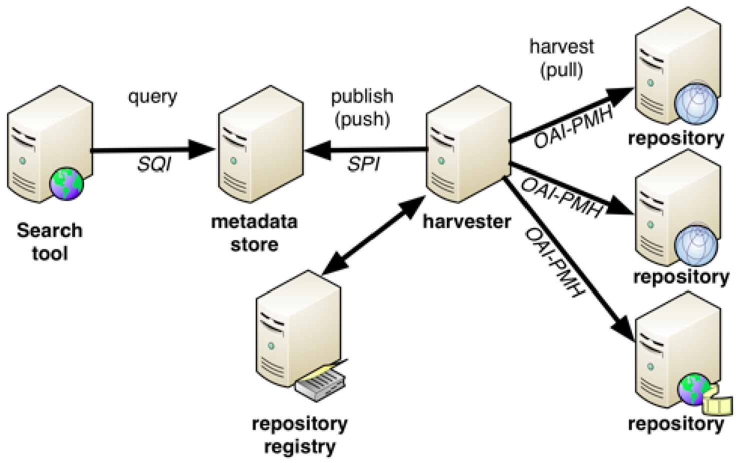

Figure 3.4.: The OICS architecture (courtesy of Stefaan Ternier) (Ternier et al., 2010)

As shown in figure 3.4, the content is harvested from different repositories and pushes the content's meta-information onto a storage which then is accessible by search requests. The OICS can therefore build instances of entire domain models, and, when matched with requirements for gaming, a game domain model. This means that it supports instantiating the domain model for game-based learning, so that it helps the design. Although there are still some unsolved issues regarding the implementation part of IMS-LD, with LAMS and EMERGO there exist practically usable authoring and deployment environments that are using virtually the same notation and functionality as IMS-LD. For both there exist working examples of learning games. Well noted, IMS-LD has its primary power to integrate diverse learning activities into Learning Management Systems and sequence them logically. Coming from the gaming side (to integrate learning processes into a game design), other approaches are more sensible such as using Learning Outcome Definitions.

The notion of game design patterns can also be reflected in the IRM by formalizing the more structural type of these patterns (such as storytelling and game-sequencing patterns) for example in BPMN notation, hence, providing important guidelines for the rule set of a game and, on the technical side, the capability to be translated into implementation stubs. In this respect much can still be learnt from the example of Interactive Fiction we mentioned, which is using its own standards that are not (yet) covered by the IRM.

3.5. Conclusions and Outlook

In this paper e-learning standards were analyzed for their appropriateness for game-based-learning. It is concluded that there are some issues, but also a lot of potential. While the game industry undoubtedly has a wide variety of de-facto standards for designing games, these often lie hidden behind the walls of large corporations that have to protect their assets. On the e-learning side, it was easier to find openly documented standards relevant to design, more of the type of "de-jure" standards (see Sloep (2002) for de-facto/de-jure discrepancy).

The synthesis of both gaming and learning can be considered from the game perspective, where the game logic or story components trigger learning processes, or, vice versa, from the learning perspective, where learning control structures define the gaming elements. By analyzing the IRM, missing links were identified between gaming and e-learning. While the game-driven perspective produced more convincing results regarding the user experience, the learning-driven perspective had advantages regarding reusability. The outcome of this observation is that there needs to be more harmonization between game design and e-learning design, for example a technical solution that makes it possible to use IMS-LD directly without encountering limitations as described by Gruber et al. (2010). Vice versa, the IRM could profit from the incorporation of standards derived from game design, such as structural game design patterns that encapsulate practical experience of successful learning games, hence contributing to a corresponding domain model.

Overall, the IRM, in its purpose to agglomerate various e-learning standards into a functional concept, shows promising directions, because it helps avoid the hazard of using standards that overlap and cause redundancies, as well as conflicting standards. However, there still needs to be work done for finding a suitable domain model to be instantiated in the IRM for the use of game-based learning. To get suitable findings for this, future research needs to include a more extended testing of available e-learning standards for the use of gaming while continued work on interoperability standards is needed on the technical side, a direction the creation of the OICS points us into.

Part II.

Experimental Findings

Chapter 4.

A Social Game for Ubiquitous Learning Support

Abstract: In this chapter[1] we describe a social learning game we implemented to evaluate various means of ubiquitous learning support. Making use of game design patterns it was possible to implement information channels in such a way that we could simulate ubiquitous learning support in an authentic situation. The result is a prototype game based on the board game "Scotland Yard" in which one person is chosen randomly to become "Mister X", and the other players have to find clues and strategies to find out who is the wanted person. In our scenario we used 3 different information channels to provide clues and compared them with respect to user appreciation and effectiveness.

4.1. Introduction

In the field of ubiquitous learning technologies, one of the recent developments is the use of awareness indicators for learning support. The approach proves to be of advantage for triggering cognitive processes that relate to the self-reflection of the learner's progress, both in an individual and social dimension. While this approach as such has been extensively discussed from a theoretical perspective (Ogata and Yano, 2004) one of the shortcomings is the application level, where a meaningful use is scarce in terms of both to engagement and maintenance. The direction taken in this research effort deals with applied game patterns for

[1] This chapter is based on: Kelle, S., Börner, D., Kalz, M. and Specht, M. (2010). Ambient Displays and Game Design Patterns. In M. Wolpers, P. A. Kirschner, M. Scheffel, S. Lindstädt and V. Dimitrova (Eds.), Sustaining TEL: From Innovation to Learning and Practice, Proceedings of EC-TEL 2010 (pp. 512–517). LNCS 6383. Berlin, Heidelberg & New York: Springer.

ubiquitous learning, implementing Ambient Information Channels (Specht, 2009) by use of game design patterns in a reusable and interoperable way, as briefly explained in chapter 2.

In this chapter we will describe our experiences with a social learning game we implemented to bring to life those information channels. Making use of game design patterns it was possible to implement ambient information channels in such a way that we could simulate a ubiquitous learning environment. The result is a prototype game based on the board game "Scotland Yard" in which one person is chosen randomly to become "Mister X", and the other players have to find clues and strategies to find out who is the wanted person. In our scenario we used three different information channels to provide clues and compared them with respect to user appreciation and effectiveness. The theoretical models underlying these principles are also mentioned in chapter 2.

4.2. Relation to Game Design Patterns

There are different ways to provide informational awareness within ubiquitous learning environments in a contextualized manner. One of the most motivating and versatile ways of doing so is the methodology of serious games and game design patterns. The discussed information channels can technically be realized as game elements, giving clues about the game's storyline or progress of opponents or collaborators. As described in chapter 2, in game design, such elements are formally described as game design patterns. These can be matched with educational purposes in order to foster certain cognitive processes and sustain motivation. Similar to the Web 2.0 patterns (Syvanen et al., 2005), from a technical design point of view the use of such pattern has several advantages supporting reusability and interoperability (Schilit et al., 1994). A pattern consists of several data fields in which there is information on the pattern itself, its functionality, its consequences and examples (Björk and Holopainen, 2004).

4.3. Research Objectives

The combination of the game-based and ubiquitous learning perspective forms the linkage between the theoretical concept and its implementation. While the concept of information channels is the theoretical construct we used for our basic design, the corresponding game design patterns formed the basis for the actual implementation of our prototype. In our study we focus on the following research questions:

1. Do alternations in use of different information channels influence the user activity and appreciation?

2. Does the use of these information channels create a meaningful and productive environment to foster social collaboration?

Different patterns were selected to according to the different information channels used. Social, workspace, and task awareness were identified as the awareness types that provide the most support for a social game setting where information is shared and distributed across different contexts. Social awareness reflects how the other participants are progressing in comparison to the individual progress, we decided to implement this with a competition pattern. Competition can be a social concept especially when competing teams are formed. In a more fuzzy sense competition also would have a social dimension because it draws attention and creates a "motto" for social interaction. According to OReilly (2007) competition is "the struggle between players or against the game system to achieve a certain goal where the performance of the players can be measured at least relatively".

Workspace awareness facilitates different types of resources supporting ubiquitous learning in a shared workspace. These resources are fed into the system and visualized using various displays. Game elements in this case can be realized using the Clues and Gain Information pattern. The clues pattern is described by Björk and Holopainen (2004) as "the game elements that give the players information about how the goals of the game can be reached". The Gain Information pattern is described as "the goal of performing actions in the game in order to be able to receive information or make deductions".

Task awareness supports the learner by facilitating and indicating the accomplishment of goals. Applying a goal pattern thus extends the abstract task into a concrete set of actions the participants can choose from, for reaching a goal, i.e. accomplishing the task. Being aware of the progress in accomplishing the task, individually or socially, creates an additional clue with respect to keeping up a certain momentum of motivation, which is supported by the score pattern, where score "is the numerical representation of the player's success in the game, often not only representing the success but also defining it" (Björk and Holopainen, 2004).

4.4. Method

Based on the previous analysis and the elaborated research questions a technical design has been implemented covering different design dimensions for the selected awareness types. A main point of interest was how the implementation got assimilated and perceived in a social setting simulating a ubiquitous learning environment. Furthermore the implications for its usage in a game based learning scenario were assessed experimentally.

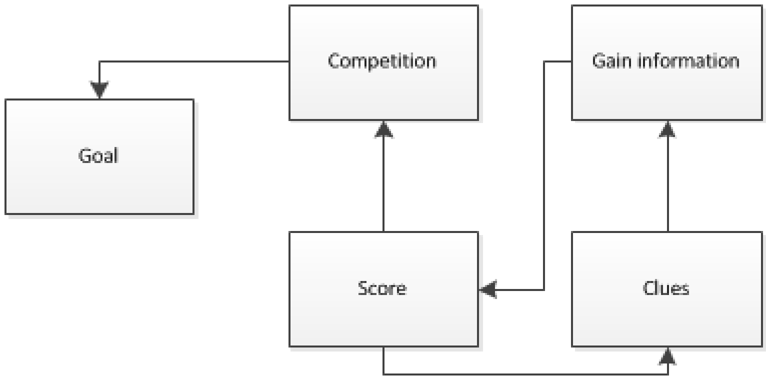

Figure 4.1.: Core structure of the game with patterns relevant to the awareness types

Figure 4.1 shows how the mentioned game patterns are interdependent. While clues could come from different sources it is noteworthy that a reflection of score would likely be a clue in itself, enabling the user to gain information, necessary to take the right decision that leads to an increased score to compete with other players and ultimately to reach the goal: to win the game. More concretely it was assessed which types of awareness are best to be targeted by which contextualized information channels: professional information was displayed in the workspace environment, while social and personal information was displayed in a social environment (a meeting lounge and coffee bar). Reflecting the current score as well as the status of the game finally provided task awareness. On day one, the information clues were given via email only, on day two they were given only with information displays, and on day three we used both channels. The information distribution channels were therefore mostly represented by the clues pattern, while the other patterns supported the mechanisms to generate more clues. Due to the somewhat volatile conditions of the experiment (it was not clear how many of the event's participants would be willing or eager to join the game), the experimental design was planned from a formative study perspective.

4.5. Implementation

The scenario selected for application of the game was at a seminar-style international meeting of PhD students of educational technology and a set of renowned instructors drawn from around Europe (The TenCompetence Winter School). In this setting, the authors implemented a social learning game based on the board game “Scotland Yard”, in which one of the participants was assigned the role as “Mr. X”, and the other players needed to find out by using various clues given according to social, workspace and task awareness.

Figure 4.2.: Authentication with the “flar toolkit”, a software solution that recognizes QR-codes

These information clues were derived from a user database that was generated from a questionnaire in which the participants entered both professional and more personal (or social) characteristics and preferences like background, age, place of birth, favorite color, etc. The gathered data was then used to display clues on screens installed in the main lecture room (workspace environment), and in the entrance respectively cafeteria (personal and social environment). The data was grouped according to the different environments: “professional” information was displayed in the workspace environment, “personal” and “social” information was displayed in the personal and social environment.

In table 4.1, the intended learning goals are matched with the respective game goals: either finding Mr. X. or (being Mr. X.) to “escape”. The learning goals were according to the two gaming goals, either to find out as much as possible and getting to know other participants in the course of this, or, as Mr. X., to get an overview of their own social reception by noticing certain suspicions during interactions among the participants.

Figure 4.3.: The voting screen interface. A vote was placed by simply clicking/tapping on one of the names/boxes

Table 4.1.: Game objectives in comparision to learning goals and patterns used

game objective	learning objective	game patterns used
winning as normal player	getting to know people, finding out as much as possible about Mr. "X"	clues, score
winning as Mr. "X"	getting to know own social reception	clues, gain information

The following rules were given to the participants: The game was played in several rounds. At the beginning of each round one of the participants was selected as Mr. X at random. Periodically, the participants received three hints about the wanted person. These hints described Mr. X in person as well as his/her social and professional life. The task was to get information about fellow participants by getting acquainted with them and discussing who could be the wanted person. After authenticating (figure 4.2), the participants were prompted with a voting screen (figures 4.3 and 4.4) in which they could vote for the person they suspected to be Mr. X. The vote for the suspected person could be given by clicking on one of the person names. They were allowed to change their mind anytime and vote again as long as the current round was open.

The round closed once more than 50% of all participants voted for the right person OR the wanted person was not identified after giving five times three hints.

Finally, after Mr. X was revealed an according email was sent to every participant, as well as the name of Mr. X was displayed on the information displays. The score was allocated accordingly and could be found in a high score list that was also online.

Alternatively, if Mr. X was not revealed within half a day, the authors stopped the round manually and declared that Mr. X had won the game. Everybody who voted for the right Mr. X got 100 points, everybody who voted for the wrong person got −50 points, Mr. X him/herself got 200 points if not revealed, and −100 points were the punishment for not voting at all.

The game was technically implemented by making use of the Google Application Engine (GWT, 2012) and the Adobe FLEX framework (FLEX, 2012), facilitating the FLAR toolkit (FLAR, 2012).

Figure 4.4.: The voting screen interface. After several votes the size of the names changed according to number of votes, thus giving a clue about the collective "suspicion"

4.6. Results

The effectiveness of the game with respect to the prospective benefit for social interaction was monitored in two ways: the user activity (system logs) and the user response to a feedback questionnaire at the end of the event. The results of the user monitoring are shown in Table 4.2. There were 3 days with two rounds of the game each. The user activity was highest (135 votes) on the first day, slightly slacked down during day 2 (114 votes) and picked up again on day 3 (134 votes). Within the table the number of votes is broken down into intervals throughout each round of the game. It can be read that the use of both emails and information displays created the highest dispersion of vote frequency in the according game rounds, which postulates the use of these information channels was most powerful.

Table 4.2.: Frequency of Votes per Intervention

Intervention	Round	Frequency of votes per time interval (20min)								
Email	I	1	4	12	19	20				
	II	27	11	21	19	1	8	2	3	2
Ambient Display	III	13	9	6	0	2	26	5		
	IV	13	4	27	10					
Both	V	11	5	5	9	10	12			
	VI	16	17	7	12	3	19	4		

In the questionnaire we had asked the participants if they preferred being sent the information clues via email or via the information displays. 66% preferred the information displays. 63% actually preferred a combination of both information displays and emails. The game's intention was to help fostering social interaction, but only 33% of the participants thought it achieved that goal (the majority was undecided about this point). Most of the participants had the impression that the game rather helped fostering social interaction not because of specific mechanisms like "personal" or "professional" information clues, but simply by the fact that there was a game being played. In contrast to this, the questionnaire results indicate that "talking to people and pondering who could be Mr. X" influenced 44% of the participants' voting activity (the rest undecided). The dynamic voting screen (adaptive size of the name fields) had an even stronger influence (66% claimed they were influenced). The motivational power of the user authentication (figure 4.2 was only rated mediocre.

4.7. Conclusion

From a critical point of view the game in its current form and limited time frame has not proven to significantly enhance social collaboration. Due to the rising user activity it could be theorized that a growing social bond between the participants might have led to a higher incentive to play the game together, and not the other way around. Our study, however, gives indications that over a longer period of time noticeable effects possibly could be measured. Besides the evaluation of data and feedback we could notice that people would in fact talk about the game in a cheerful way suspecting each other to be Mr. X. For the use of information channels regarding the different awareness types a stronger influence was measurable for task awareness, where workspace and social awareness ranked lower.

This example shows how game patterns can affect meta-learning scenarios in a social setting. Despite this study's limitations it was possible to show tendencies, with respect to what information channels can be implemented most effectively with the help of what game design patterns. This links the concept presented here back to the principle of mapping game design pattern with learning functions, as discussed in chapter 2.

Chapter 5.

Effects of Game Design Patterns on Basic-Life-Support Content

Abstract: Based on a previous analysis of game design patterns and related effects in an educational scenario, the following chapter[1] presents an experimental study. In the study a course for Basic Life Support training has been evaluated and two game design patterns have been applied to the course. The hypotheses evaluated in this chapter relate to game design patterns that have been used for learning functions, expected to enhance the learning outcome and user experience. An experimental design has been carried out in order to get insight about effects of individual and combined game patterns in a Basic Life Support course. Based on the according educational objectives, the effects of two different game design patterns relevant for learning (a timer pattern and a score pattern) have been evaluated. This game was prototypically developed targeting the application on the healthcare domain (basic life support). The results show a significant interaction effect of the two patterns on the learning gain, as well as a strong covariate influence of the learners' age.

5.1. Introduction

The design of educational or serious games is a very complex process. Two antagonistic principles have to be united: the achievement of educational objectives (serious aspect) and meaningful gameplay (game aspect). Indeed, there are different instructional design approaches that help building the bridge between these

[1] This chapter has been accepted for publication as: Kelle, S., Klemke, R. and Specht, M. (2012). Effects of game design patterns on basic life support training content. International Journal of Educational Technology and Society.

two aspects. This can be achieved with the employment of pedagogical methods that overall help learner motivation, while adapting to the different requirements of a multitude of learning contexts, as will be described in the next section. However, on the more technical end of the scale, building learning games also to a large extent requires detailed technical modeling and implementation, a challenge that touches upon technical standards, as pointed out in a previous publication (Kelle et al., 2011a) (also included here as chapter 3).

One of the possibilities to structure and simplify the quest of "how to design learning games properly" is the principle of using design patterns by Björk and Holopainen (2004), which have been described in detail in chapter 2 of this thesis.

For evaluation of a game design, in the end, play-testing (Schell, 2008) is necessary, which yields information on the user experience. The limitation here is that end-user testing brings the risk of not giving insight on what patterns exactly have contributed mainly to the success or failure of the game. In the experimental context, it is therefore essential to alternate between certain combinations of patterns to isolate what makes the game work and what not. Hence, for iterative game design incorporating end-user testing, this approach also bears high potential.

This chapter describes an experiment based on previous research in which we have analyzed pattern-based approaches in the field of commercial game design (Björk and Holopainen, 2004), provided a mapping onto learning functions and educational objectives, and evaluated the mapping with experts in Technology Enhanced Learning. While the method of developing games with the help of game design patterns is common sense, in the field of education, evidence of the efficiency of such a pattern-based serious games is scarce. In the following section the main existing findings will be discussed. After that we describe an experiment that applies two selected game patterns in a learning game and evaluate their effects on knowledge gain and user experience.

5.2. Related Work

In chapter 2, we mentioned literature evidence for use of patterns in serious gaming; however, on a fairly general level. In addition, some other relevant leads exist which show more practical findings, together covering a relatively broad range of learning contexts. We will briefly give an overview of what has been reported by the research community.

Gunter et al. (2008) combine educational theories with a model for the design process they call RETAIN (Relevance Engagement Translation Assimilation Immersion Naturalization), which they base on well-established theories of Gagné and Keller (Gagné, 1985; Keller, 1983). The strength of this approach is argued to lie in the employment of a sound theoretical foundation relevant in motivation psychology and instructional theory. However, although the approach is pointing into the direction of drawing conclusions for the application in a pattern-based design methodology, the implementation and evaluation remains future research. Another point to be noted is that the authors address an abstract level of learning, such as the cognitive, affective and psychomotor learning domains, without targeting an actual outcome oriented learning context, specifically.

Mor et al. (2007, 2011) choose an experience driven approach that is closer to the technical implementation side, but limits itself to the context of secondary mathematical education. They have made first experiences with using game design patterns for learning in the Kaleidoscope Project (Project, 2011), when the objective was teaching Mathematics to young learners, deriving a more general pattern based approach for the use in Technology Enhanced Learning. These findings led to the implementation of a web-based tool that enables the creation and archiving of design patterns.

An example for such a design pattern would be the "crescendo" pattern that deals with the problem of emerging discussions in a learning environment, spiraling towards a more rhetorical than the (more desired) reflective mode. Again, the limitation here lies within the limitation to the mathematical domain, but at least parts of the patterns could possibly be generalized. For most patterns, evidence of their actual use in the learning context is given in a qualitative overview: for example, the crescendo pattern has been implemented and tested by Cerulli et al. (2007), indicating a fair level of positive impact. A detailed quantitative evaluation, however, is missing.

Shute et al. (2009) used a model driven approach for assessment based learning game design, using elements like highscore and resources patterns to build their learning games. Their target audience was K-12 education level students in Mathematics. The way they used assessments to leverage the gaming aspect in their approach was by conjoining games with "embedded" assessments that are hidden from the user. They establish the term "stealth assessment", which they exemplify by modeling a competency-driven learning paradigm applied in the game "Oblivion". The findings were that the approach of seamlessly integrating learning with a storytelling based game was successful.

Denis and Jouvelot (2005) used a best practice-based anthology of game elements in order to achieve a high threshold of motivation. Their target domain was musical education. In their approach they used a game that trained solo parts and accompaniments of certain musical pieces, training chords and scales with players taking the roles of piano players and saxophonists in pairs of two (duets), controlling the musical interface by means of standard computer gaming equipment like joysticks and gamepads. A fair deal of freedom was given to the players, enabling improvisation, giving them ownership of their interactions. In conclusion, Denis and Jouvelot summarize that "motivation theories can help designing educational games."

Dickey (2007) looked at Massively Multiplayer Online Role-Play Games, and determined several elements that take a key role for player motivation. In his overview, he outlines the element role-playing that is responsible for a high identification factor of the player and the game character. Furthermore, a high emphasis is put on the element of narrative structure, which guides the activities of the player, being responsible for a high intrinsic motivation. As a particular element relevant for the learning context is the presence of quests that address the problem-solving aspect.

The notion of design patterns for educational games can be found more explicitly in the work of Huynh-Kim-Bang et al. (2010), in which several patterns are drawn from the analysis of 20 serious games examined by the authors. They describe the following patterns: Serious Game, Game-Based Learning Blend, Instructive Gameplay, Time for Action / Time for Thought, Reified Knowledge, Museum, and Fun Reward. These patterns rank on different abstraction levels: While the first three patterns address a very broad spectrum of educational gaming, the latter four target more concrete dimensions. Time is identified here as axis both relevant for a more intensive "action-based" gaming experience, in which the player has to deal with tasks in a rapid way. On the other hand, this is counterbalanced with more contemplative phases, which yield time for thought and reflection. The pattern of Reified Knowledge, however, drives more into the direction of self-awareness of the user's progress in the game, by manifesting certain virtual objects that represent goals and results of the game learning process. Last but not least, the Fun Reward pattern aims at game elements that trigger motivation for the user's incentive to keep playing. Overall, the approach in this work provides a useful insight on how to create meaningful connections between learning and gaming. The authors state in the conclusion, however, that there is the lack of external validation.

Finally, Kiili puts forward another promising approach by aggregating a collection of educational game design patterns on his web site Kiili (2011a). His typology of patters comprises several categories: Integration Patterns, Cognition Patterns, Presentation Patterns, Engagement Patterns, Social Patterns and Teaching Patterns. For each of these categories at least one pattern has been collected so far. This pattern library is open to suggestions for new patterns and as such could become an important repository for the community of educational game designers.

With the exception of the approaches of Mor et al. (2007), Huynh-Kim-Bang et al. (2010) and Kiili (2011a), in the approaches listed above the actual formalization of game design patterns is either not very concrete, or targeting a too narrow scope to be generalized, transferred and re-used (which is really the main purpose of design patterns). The main advantage of these findings, however, is that there are several leads that point into the direction that a pattern-based approached enhances design methodology with a direct positive impact on user experience and learning outcome.

According to Mory (2004), feedback is "a process, in which the factors that produce a result are themselves modified, corrected, strengthened, etc. by that result" and "a response, as one that sets such a process in motion". The aspect that is of highest relevance here is the notion of feedback for self-regulated learning, which was discussed in detail by Butler and Winne (1995). According to them, the mirroring of feedback to the learner is of high importance to affect cognitive engagement with tasks, using feedback of intermediate and total achievements in the learning process. The reason for this lies in the fact that an improvement of the learning experience and outcome can be measured positively if learners are given the possibility to monitor and gauge their own progress during their learning activity. As described by Verpoorten et al. (2010), this condition allows the learners to scrutinize and reflect about their newly acquired knowledge, a process which has the potential for a lasting learning success.

Revisiting Kiili, more considerations are raised with respect to feedback-induced reflection in learning game scenarios. Kiili (2007, 2011b) eclectically argues for reflection as key principle in learning games. He proposes a methodology called "Reflection Walkthrough" that is derived from the user evaluation principle of cognitive walkthrough, in order to isolate potential strengths and weaknesses of a learning game design. The methodology gives insight on feedback mechanisms that trigger reflection, the support of double loop learning, and the potential risks of evaluation overhead and cognitive overload.

As a challenge that summarizes these aspects and motivates our research we quote the recommendation for future research stated by Mory (2004): "Continue to identify and test interactive patterns among the learner, the environment, individual internal knowledge construction, and varying types of feedback."

5.3. Preparations and Research Questions

In our previous research, extending the work of Gunter et al. (2006), as well as Kiili (2007, 2011b), we looked at several pedagogical theories and taxonomies (Kelle et al., 2011b) [2], which form the bridge between game design and learning goals and functions. The method employed for this "bridging" was a step-by-step algorithm that was evaluated with 10 experts in instructional technology who independently of each other mostly came to the same results for a pattern matching between educational and game design patterns. Different from Kiili's method of Reflective Walkthrough, we focused rather on the preparatory end of sound learning game design than post mortem evaluation.

In this expert interview we had asked our 10 experts to rank the matching of a choice of game design pattern with different learning functions. The results from these expert evaluation study led us to the selection of specific patterns, i.e. the so-called time limits pattern and score pattern and that these are especially well suited for the "monitoring" learning function, which enables the reflection of learning (and game-) progress to learners. It turned out that the score pattern achieved an average ranking of 4.64 (out of 5) for the learning function of "monitoring", and the timer pattern achieved a ranking of 4.2. These patterns can be

[2] This reference is also included as chapter 2 in this thesis.

found in Björk and Holopainen's compendium about game design patterns (Björk and Holopainen, 2004), and are described as follows:

- The time-limit pattern is described as the pattern for completing an action, reaching a goal, staying in a certain mode of play, or finishing a game session with a limit based on either game time or real time.

- The score pattern is described as the numerical representation of the player's success in the game, often not only representing the success but also defining it.

These patterns individually also showed to have a relatively big disagreement factor compared between the experts' ratings. We wondered about this and therefore decided that this requires further examination. In the experiment for this chapter we have used a classic model of three experimental groups and one control group, which account for the different possible combinations of both time-limit and score pattern (for details see section 5.4). Henceforth, we refer to the different treatment groups as such:

- T0 is the control group in which none of the patterns have been applied.

- T1 is the group that only has been exposed to the time-limits pattern.

- T2 is the group that only has been exposed to the score pattern.

- T3 is the group that has been exposed to both score and time-limits pattern.

As target domain the medical topic of basic life support and first aid was chosen, because the topic is relevant, indifferently of demographical factors, for the simple reason that everybody is at permanent risk to run into an emergency situation of serious gravity (either as victim, causer or bystander). We thus controlled the risk of introducing a bias of intrinsic demotivation due to possible lack of interest in the learning content. As source for the learning content we took the guidelines available on the European Resuscitation Council's web site (ERC, 2011).

The objective of the learning activity in this experiment was the training and reactivation of basic knowledge relevant for the learner's reaction speed and quality of decisions in emergency situations that require a first-aid response. Hence, the main educational objectives beside knowledge gain and refreshment of existing knowledge were fast reaction times. The relation to the learning function "Monitoring", which was strongest rated by the experts in our preparatory study was also considered for the choice of patterns applied. Monitoring in this case entails the reflection of progress and success, mirrored to the learner throughout the progress of the game.

Therefore, the choice of game design patterns for this experiment was narrowed down to what could possibly best link to the main learning goals: improvement of reaction speed and quality of responses and creating corresponding in-game awareness thereof. In order to cater for an elicitation of high response quality, mirroring of the user's performance was needed. The most obvious way to do that was to display a game score during the experiment; in order to enhance reflection for motivation and self-awareness, as consequence of a self-monitoring learning function. The users could thus monitor their performance and gauge their own skill levels on the fly.

The other objective of interest was fast reaction time. Here, the best matching design pattern was the time-limits pattern, implementing a game element that creates a time constraint and displays a timer to the user. In order to advance in the game successfully, the user interaction had to be performed inside that time limit (in our case, 60 seconds per game unit). While the level of realism in our serious game indeed was not the highest due to technical limitations, the time limit introduced a certain notion of stress, which according to Maule and Edland (1997) can have an effect on decision framing (the opposite decision can be taken if under time pressure). In our case the purpose was to create a more realistic scenario as well as train the users for quick decision-taking. According to Ben Zur and Breznitz (1981), time pressure also can have the positive influence on a subject to take decision that is less risky than taken without time pressure. The main objective of our experiment was to evaluate effects on knowledge gain and motivation catalyzed by the time and score patterns applied on learning content. The research questions and hypotheses derived hereof are stated as follows:

(1) Will the knowledge gain of participants be significantly increased by the application of the timer and score design patterns?

Hypothesis. Knowledge gain will increase when both patterns are applied, in comparison to the application of only one pattern, or with none pattern, such that the knowledge gain of T3 will be bigger than of T2 and T1, and the knowledge gain of T0 is smallest.

(2) What is the role of age of participants, and previous knowledge related to medical, computing and computer gaming experience? What are correlation effects and covariates?

Hypothesis. We expect that the effects of time and score on the knowledge gain are independent of other variables like age, previous knowledge and computer gaming experience.

(3) What impact can be measured for the user experience in different groups and subsets of groups?

Hypothesis. The application of game design patterns have a positive impact on user experience, which we monitored in further dependent variables like perceived suspense, perceived knowledge gain, enjoyment and users' score in the game.

5.4. Method

In the operationalization we used two independent variables, i.e. we combined the use of the time-limit pattern and the use of a score pattern applied to the learning content. This resulted in four different treatments combining the two levels of the variables. Regarding the treatment groups, a 2 × 2 matrix design with 3 experimental sample groups and one control group could be formulated (cf. table 1).

Table 5.1.: The different treatments / samples

	Time Limit Display On	Time Limit Display Off
Score Display On	T3 = ScoreTime. Both time limit and score pattern	T2 = Score. Only score pattern.
Score Display Off	T1 = Time. Only time limit pattern.	T0 = Control. No game design pattern.

As dependent variables we measured knowledge gain, user appreciation, game score, and perceived knowledge improvement. These dependent variables were measured with tests after the treatment (in the case of knowledge gain: before and after). Furthermore, we calculated the knowledge gain by using questionnaires applied before and after the treatment, making use of

- multiple-choice questions for scenarios upon encounter of a victim in traffic, indoors, outdoors, and revival scenario,
- test questions for terminology of AED (Automated external defibrillator) and CPR (Cardio-Pulmonary Resuscitation), as well as how to perform CPR.

The knowledge gain was calculated as the difference of the sums of the number of correct and incorrect answers (see formula in results section). User appreciation was measured in terms of enjoyment of users rated on a Likert-scale. The game score was the actual final score the users achieved in the game, and perceived knowledge improvement was a self-assessment of confidence about the user's knowledge, on a Likert-scale. To complete the portfolio of dependent variables, we also focused on user experience, and asked the users how suspenseful they found the game, and how well they had understood how the game works.

As control variables demographic information and previous experiences with computer games and Basic Life Support has been ascertained in the pre-questionnaire. In total 133 subjects participated in the study. These 133 subjects formed 4 different treatment groups, randomly assigned according to the experimental design. In group T3 there were 36 subjects, in group T2 there were 38 subjects, in Group T1 there were 35 subjects and in group T0 there were 24 subjects. Overall, there were 47.4% of female participants and 52.6% male, with similar group distributions. The average age of participants was 32.87, and 62.9% had a university degree or higher education level.

Table 5.2.: Report about descriptives of test samples

Group	Measure	Age	CompLit	CompGLit	MedKnowl	FirstAid
Control	Mean	41.52	3.3750	2.4800	2.68	1.80
	N	25	24	25	25	25
	Std. dev.	14.295	.82423	1.41774	.988	1.472
Score	Mean	28.05	3.6842	3.5789	2.79	1.13
	N	37	38	38	38	38
	Std. dev.	6.105	.87318	.94816	.811	1.143
Time	Mean	30.23	3.7143	3.2857	2.37	.69
	N	35	35	35	35	35
	Std. dev	9.726	.75035	1.04520	.843	1.207
ScorTime	Mean	34.36	3.7838	2.7667	2.57	1.30
	N	36	37	30	37	37
	Std. dev.	10.450	.94678	1.22287	.987	1.175
Total	Mean	32.86	3.6642	3.0938	2.60	1.19
	N	133	134	128	135	135
	Std. dev	11.125	.85790	1.20653	.908	1.277

The age distribution per group was significantly differing in the treatment groups, due to the random assignments: participants were older in the control group where the average age was 41 years, with the highest standard deviation. Overall there were 76 participants from Asia, 22 from America, and 35 from Europe, fairly well covering a broad range of different backgrounds. In the pre-test questionnaire, participants were also asked to give detail about their previous experience and knowledge about the topic. There was an average medical knowledge of 2.6 (out of 5), computer literacy of 3.7, and computer game literacy of 3. Most participants previously had taken none (35%) or one (37%) first-aid course (cf. table 5.2).

The knowledge gain was calculated as follows:

$$K_{gain} = \sum S_{post} - \sum S_{pre}$$

with S_{post} denoting the score ($S = 0$ if incorrect, or $S = 1$ if correct) of correct answers given in the post-test, and S_{pre} denoting the score of correct answers given in the pre-test. If the sum of correct answers was higher in the post-test than in the pre-test, it meant there was a positive knowledge gain. If it would have been lower in the post-test than in the pre-test there would have been a negative number as result, which would mean that somebody knew “less” than before.

5.5. Apparatus

Figure 5.1.: The timer bar is diminishing as time progresses. This simulates a certain urgency of the choice to be made. The score is being reflected as well, which enables participants to gauge their performance on the fly.

The experiment was implemented by using the Emergo Toolkit (Nadolski et al., 2008), which is a java-based application framework and authoring environment for web-based learning games. For our aims this solution provided the right characteristics, because it was possible to create a learning game experience that has almost no distraction elements (user registration dialogs, social network feeds, etc.). In figure 5.1 it is shown how the two patterns were realized in the user interface.

5.6. Results

Hypothesis 1. Knowledge gain will increase when both patterns are applied, in comparison to the application of only one pattern, or with none pattern, such that the knowledge gain of T3 will be bigger than of T2 and T1, and the knowledge gain of T0 is smallest. While the biggest knowledge gain could be measured when both patterns were applied, the second-best learning result was achieved in the control group where there were no patterns applied. Table 5.3 shows the knowledge gain results.

Table 5.3.: Average values of knowledge gain according to the 4 different combinations of 2 patterns.

	Score On	Score Off
Timer On	KnowGain = 1.9167 Std. Deviation = 1.79483	Knowgain = 1.4286 Std. Deviation =1.57715
Timer Off	KnowGain = .9211 Std. Deviation =1.32301	KnowGain = 1.6667 Std. Deviation =1.43456

A univariate analysis showed significant effects when measuring between-subjects effects on knowledge gain ($F = 5.104$) at a significance of $p = 0.026$ for the combined treatment with both patterns, while the knowledge gain for both treatments with only 1 pattern or the baseline without any pattern was not significant (cf. table 5.4).

Table 5.4.: Tests of Between-Subjects Effects on Knowledge Gain

Group	F	Sig.
T0 (control group)	.506	.478
T1 (time limit pattern applied)	1.924	.168
T2 (score pattern applied)	.222	.638
T3 (both patterns applied)	5.104	.026

With respect to hypothesis 1, the result showed that the hypothesis could be verified only partially. While the application of both patterns elicited the highest knowledge gain significantly, the other treatments had no significant knowledge gain; with the time limits pattern ranking second. This hints at a strong combination effect of both patterns.

Hypothesis 2. We expect the effects the time and score patterns on learning gain to be independent of other variables as age and previous knowledge, and computer game experience. Here, we found that the age correlated (between subjects) significantly with knowledge gain in the groups for the treatments of both time and score patterns ($p = 0.006$), as well as with only the time pattern ($p = 0.044$), while the control and score groups did not show such a significant correlation. It is also remarkable that there was no significant correlation between previous medical knowledge as well as computer literacy of the participants and knowledge gain. The correlation between number of times of already taken first aid courses

Table 5.5.: Analysis of Variance, using Age as covariate

Group / Covariate	F	Sig.
Age (covariate)	8.960	.003
T0 (control group)	.535	.466
T1 (time limit pattern applied)	2.928	.090
T2 (score pattern applied)	.110	.741
T3 (both patterns applied)	.619	.433

and knowledge gain showed to be significant in the control group, thus indicating that the absence of game patterns is best for those subjects who had taken already several first aid courses. For people who had already a fair deal of computer gaming experience, a significant correlation was found in the group for the treatment with the score pattern. Using a covariate analysis we established that there was a significant effect of age on the results, which appeared to occlude the actual effect on knowledge gain (see table 5.5, the effect of the age was large and highly significant with $F = 8.96$ and $p = 0.003$). Consequently, we split the test population in halves, at the median of the age of 30 (size of subgroups was slightly bigger in the group of younger participants with ratio 71/62). We then tested again for significance of the effect of the treatments on knowledge gain, for younger and older participants separately (cf. table 5.6). The results showed that there was no significant effect of any treatment on the knowledge gain in the set of younger participants, but the effect on the knowledge gain of older participants was significant in the subgroup that had the "time limit" treatment ($F = 6.835, p = 0.011$).

This result indicates that the hypothesis 2 was refuted with respect to the strong covariate influence of age of the participants. After decomposing the sample into subgroups regarding the age split of "young" ≤ 30 and "old" > 30 years it was only the time-limits pattern that showed a significant effect on knowledge gain in the older set of participants.

Hypothesis 3. The application of game design patterns have positive impact on user experience, which we monitored in further dependent variables like perceived suspense, perceived knowledge gain, enjoyment and users' score in the game. To examine results for this hypothesis (cf. table 5.7), we tested effects on rather experiential dependent variables. It turned out that the effect on actual points

Table 5.6.: Analysis of variance using age split

Age split	Group	F	Sig.
young	T0 (control group)	.791	.377
	T1 (time limit pattern applied)	.291	.592
	T2 (score pattern applied)	.045	.832
	T3 (both patterns applied)	1.223	.273
old	T0 (control group)	.354	.554
	T1 (time limit pattern applied)	6.835	.011
	T2 (score pattern applied)	.797	.376
	T3 (both patterns applied)	1.832	.181

achieved in the game was significant in the group of older participants that had received the treatment with both time and score pattern ($F = 5.411, p = 0.024$), while in all other groups and subgroups there was no significant effect on points achieved. Arguably, the points achieved are not directly a "user experience" factor, but as it is directly giving feedback to the user's performance we included it in this observation.

Table 5.7.: Analysis of experiential dependents, using age split

Age split	Group	Score		Suspense		Perc. K. Gain	
		F	Sig.	F	Sig.	F	Sig.
young	T0 (control group)	.005	.943	.839	.363	.079	.779
	T1 (time limit pattern applied)	1.210	.275	2.566	.114	.004	.949
	T2 (score pattern applied)	.226	.636	.180	.673	.208	.650
	T3 (both patterns applied)	1.210	.275	7.516	.008	.008	.930
old	T0 (control group)	2.522	.118	1.554	.217	.418	.893
	T1 (time limit pattern applied)	.350	.557	.015	.902	.954	.333
	T2 (score pattern applied)	.003	.960	.365	.548	7.519	.008
	T3 (both patterns applied)	5.411	.024	2.363	.130	7.065	.010

Another dependent variable was linked more closely to user experience: the participants were asked how much they had enjoyed playing the game. Here, no significant effect could be measured in any group (therefore not listed in table 5.7). However, when asked about how much suspense they had felt during playing the game, a significant effect ($F = 7.516, p = 0.008$) could be measured in the group of younger participants that had received the treatment with both score and time patterns. Interestingly, looking at perceived knowledge gain, in the group of older participants the treatment with the score pattern showed a significant effect ($F = 7.519, p = 0.008$) and the treatment with the time and score pattern showed a significant effect of similar value ($F = 7.065, p = 0.01$). There was no significant effect in any other variables and treatment groups, or in the subgroups of younger participants.

5.7. Discussion and Conclusion

Looking at the main question of this research, i.e. if the combination of both patterns has positive effects on knowledge gain and user experience, the results show overall the tendency that this is the case, especially for participants of older age. On the one hand, this stresses the fact that game design patterns should not exist alone; indeed, by the very nature of their definition according to Björk and Holopainen (2004), choosing one game design pattern in most cases automatically requires the presence of other game design patterns, and so forth, inductively. The fact that we observed in our limited setup that already the presence of two game design patterns exhibited a significant combination effect on user experience and player score points towards the importance of interlinking such patterns and make them supplement each other so they provide a sound, holistic game design that suits the respective context.

With respect to the strong influence of age, it appeared at first that isolated game patterns have an even lower value than no game pattern at all when being applied to "gamify" learning content. It quickly became clear that age had a significant covariate effect that influenced the main result. It was, hence, necessary to analyze the data more in-depth, with splitting between younger and older participants at the median value of 30. This revealed that the first observation could only partially be confirmed. A significant effect on knowledge gain then only could be monitored for the treatment with the "time limit" pattern, indicating that stress induced by a timer has a positive influence on knowledge gain for older participants. An informative addition to this observation could be made when not just looking at knowledge gain, but also at other dependent variables. Indeed the actual score reached in the game and perceived knowledge gain showed significant benefit in the group of older participants who had the treatment with both score and time patterns.

It could also be observed that younger participants showed a fair deal of inertia with respect to the effect of different treatments on learning outcome. What was interesting, however, was that the treatment with both patterns in the younger group was perceived as most suspenseful. A potential interpretation of these findings could be that younger participants take more notice of the gameplay as such while not being as responsive with respect to the intended learning objective. While correlations might partially give insight to the reasons of the significance of effects on knowledge gain when looking at the whole test sample, the correlations were no longer significant after splitting between younger and older participants. This indicates that in future research quasi-randomization with equal age distributions in all treatment groups will be required.

Subsuming, our result has limitations because we only tested two patterns and the result was not significant for the younger half of the test sample. Future research in this direction should therefore try different contexts with different patterns, with particular awareness of age of the participants, and extend the fundus of data with similar or bigger sample sizes. The theoretical background of this study, which largely foots on the paradigms of feedback and reflection, seems to withstand being put to the practical test. This can be concluded because the suggested benefit of design patterns for the gamification of learning content could be validated especially in the self-directed learning context, which is more relevant to older participants. It is, however, necessary to disclaim that our target domain of basic life support and first aid training usually is organized in a quasi-curricular fashion under the surveillance of expert instructors. The intrinsic motivation, though, to enroll for first-aid training, tends to be higher for more mature participants, as the necessity for such undertaking depends more on personal insight and experience. As such, design patterns for learning games seem to be well suited for the life-long learning context.

Chapter 6.

In-depth analysis of Timer and Score Patterns applied on BLS Content

Abstract: This chapter [1] reports about whether implementing game design patterns into an e-learning environment would enhance learning processes and knowledge gain. 227 participants completed an e-learning course on basic life support. They participated in a quiz and received feedback on their performance after each quiz question. Two game design patterns were applied, i.e., a timer and a score display (i.e., feedback on the amount of correct answers). Moreover, based on prior research, age was taken into account as a covariate. Results overall showed a slight improvement in knowledge gain for treatment with both patterns, however, only participants who perceived the game as suspenseful had a measurably significant effect on knowledge gain. An additional investigation on users' perception of these two gaming patterns by means of eye-tracking (i.e., measuring visual attention) and verbal protocols (i.e., measuring cognitive processes) was carried out. These measures revealed that the timer element only became relevant when the actual time limit was reached and otherwise neglected.

6.1. Introduction

An educational game usually has to fulfill different requirements that relate to learning success and user experience, which can be evaluated post-hoc in terms

[1] This chapter is based on: Kelle, S., Jarodzka, H., Klemke, R. & Specht, M. (2012). In-depth analysis of Timer and Score Patterns applied on BLS Content. Submitted to Computers & Education Journal.

of overall effectiveness. To improve the design process of learning games, it is essential to identify individual game elements relevant for the success (or failure) of a game design. Like before, the approach is based on the theory of game design patterns Björk and Holopainen (2004).

In the meantime, both Björk and Holopainen have continued to explore the field of digital games further. Recent literature describes efforts of Björk's team to build on the theory of game design patterns and to use them, for example, in character design. They do this both in terms of overall characteristics (Lankoski et al., 2011) as well as in-game dialogues (Brusk and Björk, 2009). Holopainen and colleagues have been focusing on alternate reality games(Stenros et al., 2011). While these findings report on the usefulness of game design patterns and their application, our approach intends to close the gap that results from the questions that emerge upon synthesis of game design patterns and learning processes/functions.

While the choice of such design patterns varies from game to game and thus seems volatile, some classes of such patterns reoccur. In an earlier study, we defined such a special class, namely game design patterns that are supposed to support learning (Kelle et al., 2011b)[2].

To systematically investigate the efficiency of these game design patterns for learning games, we decided to choose two game patterns that were ranked highly in terms of their likelihood to support learning by experts of the field (Kelle et al., 2012)[3]. These patterns were then implemented on top of an exemplary learning content with characteristics that bear intrinsic learning motivation for life-long learners: first aid and basic life support. The patterns chosen were the "timer" pattern, and the "score" pattern. Both are relatively universal game design patterns that are particularly beneficial for use in the learning domain: the timer pattern enhances the perception of urgency of a simulated emergency situation, adding realism. The score pattern helps reflecting quality of response to the user and gauging their learning/gameplay progress. The presence of these two patterns was varied systematically in our previous study.

In a nutshell, the experiment produced promising results. Participants that received both gaming patterns not only showed a higher knowledge gain than all other groups, but also their user experience was enhanced (measured in terms of user appreciation). However, variations between the treatment groups regarding participants' age resulted in a covariate effect. After splitting the population into similarly sized subgroups at the median of 30 years of age, significant effects with positive knowledge gain were only found in the group of older participants.

However, in order to draw conclusions on differential age effects, the variable "age" must be varied more systematically. Hence, in a follow-up experiment the following modifications were implemented:

[2]This article is also included in this thesis as chapter 5.
[3]This article is also included in this thesis as chapter 2.

- Fully automatized randomization using the linear congruential generator method as algorithm, in order to assign users to one of the four treatment groups with equal probability upon entering the game

- Automatic logging of user interactions and system variables like score and time spent on each item

- Pre- and posttest was included in the game unit itself, eliminating possible errors for mapping user IDs with datasets

The question of target groups' different age classes has been discussed by Ratan and Ritterfeld (2009). They suggest: "Serious games that are used beyond the high school level do not target specific age ranges". Also, by the nature of the life-long-learning context we addressed, a wide spread of age of potential target users occurs. Therefore, an effect regarding the learning benefit and user experience with respect to certain age groups is a matter of ongoing discussion. The 2011 Horizon Report (Johnson et al., 2011) points at the importance of game-based learning for adult learners and anticipates a growing trend into this direction.

From a more general perspective, the theory of feedback and reflection (Mory, 2004; Butler and Winne, 1995) is of relevance. Feedback for self-regulated learning is one of the principles that help the learners gauge their own progress and reflect about their newly acquired knowledge. However, these principles do not work in this context without situational awareness. Here, the theory of Endsley (2000) links in: Situational awareness consists of perception, comprehension and projection, which run in a loop that is driven by feedback. In our approach, the conjecture is that the game design patterns we use help to enhance this loop, by raising the users' situational awareness especially in the perception stage regarding time awareness and quality-of-response-awareness.

In the following, we will first describe the theoretical background that explains the choice of patterns and the experimental approach. Then we will report about methods and experimental results regarding the age effect, as well as overall results concerning game design patterns and their effects on knowledge gain, user experience and retention. Finally, we also conducted a qualitative analysis of user interaction using an eye tracking sensor to help interpreting the quantitative results, with special consideration of the importance of user interface and visual representation of the patterns. Also, verbal information (thinking aloud procedure) was used to ascertain additional information of the users' perception.

6.2. New findings since the last experiment

As described in section 5.3, the choice of the domain was made for the same reason: Relevance to a broad audience. Regarding the timer and score pattern, the implementation of these patterns also relates to the following concepts: For the score pattern, a mirroring of the user's performance was needed. This was achieved by displaying a game score during the experiment, in order to enhance reflection for motivation and self-awareness, as a consequence of a self-monitoring learning function as first suggested by Zimmerman (1990). The users could thus monitor their performance and gauge their own skill levels on the fly.

The other objective of interest was fast reaction time. For this, we used the time-limits pattern, implementing a game element that creates a time constraint and displays a timer to the user. With this time-limit, the user interaction had to be performed inside that time limit (in this case, 30 seconds per game unit was chosen because in the previous experiment practically nobody ran into the time limit). The time limit introduced a certain notion of stress, which according to Maule and Edland (1997) can have an effect on decision framing (the opposite decision can be taken if under time pressure). According to Ben Zur and Breznitz (1981), time pressure also can have the positive influence on a subject to take decision that is less risky than taken without time pressure. In a first aid scenario, it is of crucial importance not to put oneself or bystanders at risk in the course of helping a victim.

For the use of game design patterns in learning, various attempts have already been made with mixed results. One example is the work by Kiili who started a repository for game design patterns able to be used in the educational context (Kiili, 2011a): The approach intends to capture a holistic collection of educational game design patterns, yet remains incomplete. Another powerful approach (describing game design patterns for learning from a very general perspective) has been put forth by the work of Huynh-Kim-Bang et al. (2010). Meanwhile, the same research group at LIP6 Lab in Paris, however, has focused more toward using petri nets for assessment in serious games Thomas et al. (2011).

Mor et al. (2011) have taken a very precise approach on targeting formative assessment methodologies. In this case, game design patterns can be instrumentalized for evaluation purposes. It is, however, limited to math teaching in K12 education systems, which was the targeted audience for the Kaleidscope Network of Excellence (Project, 2011). The directions these colleagues have taken seem to point at a fundamental problem. Either the view is too general and difficult to apply in a concrete scenario, or too concrete, only tackling one particular aspect that is hard to transfer to other contexts. Relating to this, one of the pressing questions with the use of game design patterns in the learning context is obviously the difficulty in deciding where to start and what patterns best to use in which context.

To gain further results that help to close this gap we decided to follow through the creation of two game design patterns for learning, their implementation and evaluation, all the way down to a highly detailed level: we also looked at how these two game design patterns are processed on a cognitive and perceptual level. Cognitive processes can be investigated by means of a "thinking aloud" procedure (Ericsson and Simon, 1980). Thinking aloud is a method to capture the content of ongoing working memory processes by asking participants to verbalize them. Perceptual processes, on the other hand, can be best captured by means of eye-tracking (Holmqvist et al., 2011). Eye tracking is used to capture the movements of the eyeballs and to relate these to a stimulus on a computer screen. This helps to infer where a person looked at, for how long, and in which order. We used both methods to get further insight into the processes evoked by our choice of game design patterns.

6.3. Research Questions

As mentioned, in a previous experiment we applied two different game design patterns for use in the application on learning content: the timer and score pattern. The goal was to explore if bridging between game design and learning goals/-functions has measurable positive effects. The result of that study had pointed us towards a possible influence of the participants' age. To see if it really is significant, we tried to reproduce this effect under more realistic conditions. In this experiment, we reused parts of the previous experiment but focused on interpreting the results with special consideration of the age-effect in question. The pattern used in this study were:

- The time-limit pattern is described as the pattern for completing an action, reaching a goal, staying in a certain mode of play, or finishing a game session with a limit based on either game time or real time.
- The score pattern is described as the numerical representation of the player's success in the game, often not only representing the success but also defining it.

The crucial points that are needed to be counter-evaluated against the influence of age are the effects on knowledge gain and user experience catalyzed by the time and score patterns applied on learning content.

The research questions and hypotheses derived hereof are stated as follows:

(1) Will the knowledge gain of participants be significantly increased by the application of the timer and score design patterns? What specific characteristics of the participants are relevant for a substantial knowledge gain?

Hypothesis. Knowledge gain will increase when both patterns are applied, in comparison to the application of only one pattern, or with none pattern

(2) What is the role of age and other control variables of the participants?

Hypothesis. We expect that the effects of time and score on the knowledge gain are independent of variables like age. Other control variables like perceived suspense, stress and enjoyment, may still have a covariate impact.

(3) How do the treatments affect the retention of knowledge for the participants after an interval of 6 weeks?

Hypothesis. In the group of both score and timer pattern treatment, we can find a significant positive effect on retention (6 week interval).

(4) How does the cognitive and perceptual processes triggered by the user interaction help explain our results in further detail?

Hypothesis. Monitoring user interaction with respect to visual elements representing the patterns will reveal: the more attention of users is going to the game patterns presented in the artifact, the more effect these patterns will have.

6.4. Design

In the operationalization, we used the two patterns as independent variables, i.e., we combined the use of the timer pattern and the use of a score pattern applied to the learning content. This resulted in four different treatments combining the two levels of the variables. Regarding the treatment groups, a 2×2 matrix design with 3 experimental sample groups and one control group could be formulated (cf. table 6.1).

As dependent variables, we measured knowledge gain, user appreciation, game score, as well as perceived suspense. These dependent variables were measured with tests after treatment (in the case of knowledge gain: before and after). Furthermore, we calculated the knowledge gain by using questionnaires applied before and after the treatment, making use of

Table 6.1.: The different treatments / samples

	Time Limit Display On	Time Limit Display Off
Score Display On	T3 = ScoreTime. Both time limit and score pattern	T2 = Score. Only score pattern.
Score Display Off	T1 = Time. Only time limit pattern.	T0 = Control. No game design pattern.

- multiple-choice questions for scenarios upon encounter of a victim in traffic and revival scenario,
- test questions for terminology of AED (Automated external defibrillator) and CPR (Cardio-Pulmonary Resuscitation), as well as how to perform CPR

As control variables, demographic information, previous experiences with computer games, and Basic Life Support experience had been ascertained in the pre-questionnaire.

Additionally, we recorded the eye movements and think-aloud protocols of a subgroup of the participants. In that, we captured the total amount of time spent looking at (i.e., sum of fixation durations) of users on relevant visual elements using an eye tracker (for details see below), as well as recordings of users' think-aloud protocols, in order to gain additional insight on user interaction and its effects on cognitive and perceptual processes. This was done in a total of 8 sessions (two users per treatment) where participants were invited to our laboratory. The data were captured by using a Tobii 1750 eye tracker and then evaluated using qualitative methods.

6.5. Participants

In total, 227 subjects participated in the study. These subjects formed 4 different treatment groups, randomly assigned according to the experimental design. In group T3 there were 45 subjects, in group T2 there were 57 subjects, in Group T1 there were 60 subjects and in group T0 there were 65 subjects. Overall, there were 30% of female participants and 70% male, with similar group distributions. 28.2% of the participants were enrolled for a university degree, 50.2% already had a university degree, and 15% had a high school graduation degree.

The age distribution per group was equal in the treatment groups with an average

Table 6.2.: Report about descriptives of test samples, including age, computer literacy, computer game literacy, medical knowledge, and number of first aid courses already taken

Group	Measure	Age	CompLit	CompGLit	MedKnowl	FirstAid
Control	Mean	29.08	4.15	3.63	2.55	1.17
	N	65	65	65	65	65
	Std. dev.	8.119	.795	1.024	.952	1.098
Score	Mean	29.60	3.84	3.46	2.46	1.02
	N	57	57	57	57	57
	Std. dev.	9.556	.992	.927	.867	1.110
Time	Mean	29.15	4.10	3.47	2.40	1.22
	N	60	60	60	60	60
	Std. dev	8.518	.951	.999	.718	1.091
ScorTime	Mean	27.56	4.02	3.60	2.38	1.09
	N	45	45	45	45	45
	Std. dev.	8.253	.753	1.074	.960	1.221
Total	Mean	28.97	4.04	3.54	2.45	1.13
	N	227	227	227	227	227
	Std. dev	8.603	.856	1.001	.873	1.12

age of 28.97 years (std. deviation 8.603). Overall 59% of the participants were from Asia and the oceanic regions, 14% from America, 26% from Europe, and 1% from Africa, fairly well covering a broad range of different backgrounds. In the pre-test questionnaire, participants were also asked to give detail about their previous experience and knowledge about the topic. There was an average medical knowledge of 2.45 (out of 5), computer literacy of 4.04, and computer game literacy of 3.54. The average number of first aid courses the participants had taken previously was 1.13 (cf. table 6.2).

6.6. Apparatus and Material

The experiment was implemented by using Adobe Captivate, a flash-based application framework and authoring environment for web-based learning. Although Captivate is better known for its content production module, especially screen capturing, it also has a quiz module, which can be used to implement simple learning games. In figure 6.1, it is shown how the two different patterns were realized in the user interface.

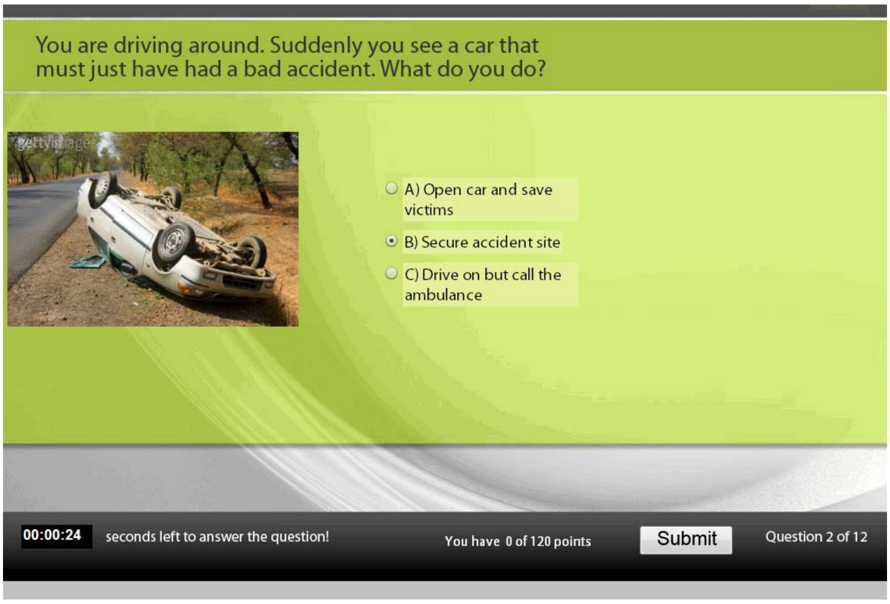

Figure 6.1.: Screenshot of learning game created with Adobe Captivate showing both patterns in the lower part of the screen

The advantage to use the quiz module of Captivate was that it was possible to build all elements of the experiment (except the retention test) into one single "unit", making it easy to allocate user interactions to one and the same identity. It was also possible to monitor individual user interactions, reaction speeds and game score.

Using the authoring environment of captivate, conditions were set to make the artifact react in a certain way to user interaction. Upon each correct reply, the score was raised by 10 points, and a feedback message was displayed. In a similar way, it was possible to show or hide certain elements depending on the value of system variables. This function was used to hide or display timer and score elements as well as triggering the automatic closure of the question when the timer ran out.

6.7. Data Analysis

The knowledge gain was calculated by counting the number of correctly answered questions in the post-test and subtracting the sum of correctly answered questions in the pre-test thereof. If the sum of correct answers was higher in the post-test than in the pre-test, it meant there was a positive knowledge gain, and vice versa, for a negative sum. Score and time spent on each item were derived from log files. Other measures like perceived suspense, stress and enjoyment were derived from direct user input in the post test rated on Likert-scales. These were then used as covariates in univariate analyses, in which the pattern treatments were independent variables. Finally, we also calculated the retention value, corresponding to the average number of correctly answered questions in a repeated post-test.

User appreciation was measured in terms of enjoyment of users, perceived suspense and stress by means of a questionnaire added to the post-test. The game score was the actual final score the users achieved in the game.

In the additional eye-tracking analysis, a purely qualitative model was applied in order to ascertain the time to first fixation of individual stimulus elements, i.e., especially the visualizations of the patterns in question. The same was done for the total fixation duration of the same stimuli.

6.8. Results

Hypothesis 1. Knowledge gain will increase when both patterns are applied, in comparison to the application of only one pattern, or with none pattern, such that the knowledge gain of T3 will be bigger than of T2 and T1, and the knowledge gain of T0 is smallest.

While the biggest knowledge gain could be measured when only the score pattern was applied, the second-best learning result was achieved in the group where both time and score patterns were applied. Table 3 shows the knowledge gain results.

Table 6.3.: Average values of knowledge gain according to the 4 different combinations of 2 patterns. (Standard deviations are presented in brackets

	Score On	Score Off
Timer On	1.4667 (1.9259)	1.3833 (1.43906)
Timer Off	1.6667 (1.53917)	1.2615 (1.7965)

A univariate analysis with "timer" and "score" as factors and "knowledge gain" as dependent variable was calculated. Results showed no main effect for the factor "timer" ($F(1, 223) = .030, p = .862$), no main effect for the factor "score" ($F(1, 223) = 1.186, p = .227$), and no interaction. ($F(1, 223) = .515, p = .474$).

With respect to hypothesis 1, the result showed that the hypothesis could not be verified, although slight positive effects were measured, which were not significant.

Hypothesis 2. We expect the effects of the time and score patterns on learning gain to be independent of other control variables such as age. Other control variables like perceived suspense, stress and enjoyment may still have a covariate impact.

In contrast to our suspicion, the covariate influence of age of the participants, as observed in the previous experiment, could not be reproduced. However, it was possible to find a significant covariate effect of the "perceived suspense" in the game on the actual knowledge gain ($F(1, 222) = 12.259, p = 0.01$), relevant to the treatment group that had both timer and score treatment (T3). One of the effects that could be measured was that there was a significant positive impact on knowledge gain in the group of participants only with the "timer" treatment, when users, in fact, took less than 150 seconds of net time to answer the questions ($F(1, 222) = 9.688, p = 0.003$).

Further analyses showed that some of the correlations between control and dependent variables were of significance. There were significant positive correlations between medical knowledge and knowledge gain in the group T2 (only score pattern treatment), as well as between the number of first aid courses taken and knowledge gain. Also, there was a significant correlation both in the control group and the group that only had the "score" treatment between knowledge gain and the actual score reached in the game. This implies that a certain level of previous knowledge helped participants to "reify" that knowledge in the respective treatment and that score reached in the game in fact reflected knowledge gain.

Hypothesis 3. In the group of both score and timer pattern treatment, we can find a significant positive effect on retention (6 week interval).

Table 6.4.: Descriptive Statistics including retention results

Group	N	Mean of Retention	Std. dev.	Willing to participate in further inquiry
T0 (control group)	7	2.8571	1.46385	42
T1 (time limit pattern applied)	18	2.6111	1.24328	42
T2 (score pattern applied)	10	2.8000	1.47573	40
T3 (both patterns applied)	12	2.7500	1.28806	36

One of the novelties in this experiment was that we could run a retention test, due to a total of 51 users responding. The problem with retention tests is that usually the response rate is much lower than the original sample size. In this case, the size was sufficient, but the distribution over the groups was not perfectly equal, for example, with 18 responders in the "timer" group but only 7 responders in the control group. The method used here was repeating the same questionnaire as in the post-test, without user experience questions. The possible score ranged from 0 (no question was answered correctly) to 5 (all questions were answered correctly). The result as such also could not satisfy the hypothesis due to the treatment with both timer and score pattern leading to a smaller retention result than the control group with no treatment (cf. table 6.4). Another observation we made, was that the number of participants in the main experiment who indicated that they may be contacted for "further inquiry" was much higher ($N = 160$) than the response quote from the actual retention test. Here the numbers (cf. table 6.4) were distributed more equally. Over the 6 weeks, the users who had the control treatment seemed to preserve the least interest to participate in further inquiry: the number of 42 participants who indicated a willingness to participate in further activities shrunk down to 7 who actually participated.

Hypothesis 4. Monitoring user interaction with respect to visual elements representing the patterns will reveal: the more attention of users is going to the game patterns presented in the artifact, the more effect these patterns will have.

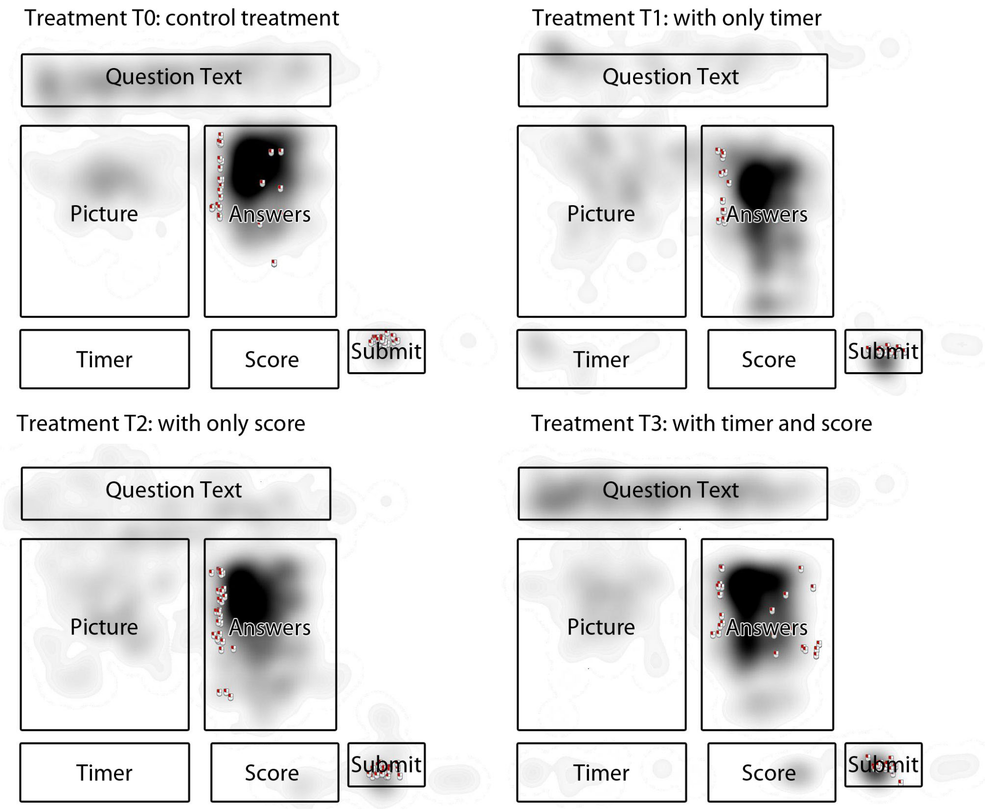

Figure 6.2.: Heat maps of the four treatments. The image shows areas of interest as well as relative frequency of fixation of elements. If an area is black, it means that more than 2/3 of total fixations were directed at that area. A light gray to dark gray area implies a low (only one or very few fixations) to medium rate.

We conducted a qualitative test on an additional sample using an eye tracking sensor to find out if the pattern elements were actually perceived by the users. The results show that the timer element was either not noticed by the participants (2 test subjects per group), or only peripherally (hence, the indication of very few gazes at the timer in figure 6.2). Generally, users did not notice the timer element, with the exception of those who actually ran out of time (in which case an additional alert popped up). The score element was noticed by everyone. As a result of the "think aloud" procedure, two out of eight users in total mentioned that they did not feel that the application was a game at all, signaling a certain dissatisfaction.

The eye tracking part of the experiment illuminates the mechanics in the user-interaction of the apparatus used in the overall experiment. Users only noticed the patterns that became relevant to them. As score (being part of the feedback system) was of "reassuring" value and helped player motivation, the timer element never really mattered unless a user ran out of time. Participants would therefore only notice the timer pattern when it "was too late" and they were confronted with the "timeout" message.

Table 6.5.: Participants' (P1 to P8) duration of time elapsed until they first looked at a screen element, in seconds

	picture	question	answer	timer	score
T0 (P1)	5.43	0.64	0.14	–	–
T0 (P2)	3.49	0.90	0.52	–	–
Mean	4.46	0.77	0.33	–	–
T1 (P3)	0.30	0.40	0.13	19.46	–
T1 (P4)	0.01	2.40	0.92	103.07	–
Mean	0.155	1.40	0.525	61.265	–
T2 (P5)	0.14	2.31	0.00	–	–
T2 (P6)	1.32	3.02	4.59	–	11.37
Mean	0.73	2.665	4.59	–	11.37
T3 (P7)	0.00	0.40	3.59	–	9.85
T3 (P8)	0.12	0.89	0.32	13.11	10.88
Mean	0.06	0.645	1.955	13.11	10.365

Table 6.5 shows how the time to first fixation supports the observation that participants have not noticed the timer until some special event occurred that made the timer appear relevant (running into the time limit). Especially in the group with only the timer pattern (T1) this is clearly the case.

Table 6.6.: Participants' (P1 to P8) total duration of fixation on screen elements, in seconds

	picture	question	answer	timer	score
T0 (P1)	19.70	28.93	70.70	–	–
T0 (P2)	24.54	25.33	118.74	–	–
Mean	22.12	27.13	94.72	–	–
T1 (P3)	6.40	2.05	8.75	0.46	–
T1 (P4)	10.93	2.47	58.74	1.76	–
Mean	8.665	2.26	33.745	1.11	–
T2 (P5)	8.58	3.33	33.70	–	–
T2 (P6)	10.36	5.90	50.93	–	2.01
Mean	9.47	4.615	42.315	–	2.01
T3 (P7)	11.67	18.60	80.96	–	0.58
T3 (P8)	20.25	57.20	101.32	4.16	6.74
Mean	0.06	0.645	1.955	4.16	3.66

The results for total fixation (table 6.6) indicate that the timer was overlooked by one of the participants with full pattern treatment (T3), as well as one of the participants with only the timer treatment (T1). One of the participants in the treatment with only score (T2) also overlooked the score element. From the verbal description, however, all of the participants who had the score treatment claimed to have noticed the score element. The participants who noted the timer did so with considerable delay (cf. table 6.5), due to running into the time limit later in the game. Another observation could be made with respect to relevant information presented in the artifact: Participants who had only one treatment spent more time on watching the picture (which was in fact a redundant element) than the participants of the treatment group with both patterns.

6.9. Discussion and Conclusion

For the assumption that the impact on learning gain is independent of user age, we can conclude a positive outcome: Our approach works with similar effect on older and younger participants because we could not reproduce any significant difference between age groups.

Although this experiment was showing positive results in general, the results regarding a pattern-enhanced knowledge gain were below the threshold of significance. There was, however, one interesting exception, namely the role of perceived suspense in the game, which showed to have a positive impact on the actual knowledge gain in the group with full treatment of both timer and score pattern. This means, that the suggested benefit of design patterns for the gamification of learning content could be validated especially in the context of perceived suspense, which is possibly relevant to participants that have not been exposed to a lot of serious games before. For a future direction, it is therefore of interest to include patterns that support storytelling and suspense creation.

Using an eye-tracking sensor, we obtained insights on how the representation of the pattern elements created an impact on the cognitive processing of the stimuli. Qualitative analyses revealed that the timer element was not received as a conspicuous feature. The eye tracking data show that participants paid very late and very little attention to this element. This finding was also corroborated by the think-aloud protocols, in which participants indicated that they had only noticed the timer after the time out notification. Visual attention needed to process the patterns was drawn from redundant information (illustrative pictures) and instead directed at more relevant information (questions and answer choices).

However, it remains a matter of discussion whether also other factors might be contributing to the result: On the one hand, our approach of using isolated game design patterns to analyse effects of games seems not to give sufficient answers with respect to the complex dynamics that make a learning game effective. Therefore, instead of examining isolated game design patterns and their individual effects, a possible next step could be to monitor effects of game design patterns being added or removed from a working learning game environment that is already composed of several other patterns. An observation that supports this assertion is the fact that participants (especially in the control group) mentioned that they did not perceive the artifact as a game. On the other hand, the amount of learning content was quite limited, partly due to the nature of the domain (there is only so much one can learn about first aid), which also limited the possibilities for assessment. Conducting a comparative study using another domain and content may, therefore, be of interest for future research.

Chapter 7.

Achievement Patterns applied on Life Science Content

Abstract: In this chapter[1] an approach is portrayed that is building on the results of the previous experiment, which indicated there was a clear link between the perceptual process and a positive outcome of the treatment. In order to account for this finding, the game design patterns used here were implemented as graphical representations of achievment badges that are clearly visible to the user. They give feedback in terms of overall progress and the learning process. The achievement badges were realized by implementing a portlet for a Liferay Wiki. Their activation is fed by process data generated from user interactions, such as time consumed and frequency of interactions. Also, some of the badges were content-sensitive such as a "deep learner" badge that was awarded upon consumption of content with elevated difficulty level. The results indicated that the game elements enhanced the user experience, but had adverse effects on learning due to distractive properties.

7.1. Introduction

The motivation for this study is that in the previous studies, there was no clear indication for the significance of knowledge gain in the gamified treatment group. However, the qualitative sub study in the last experiment indicated that the stimuli monitored had almost not been noticed by the participants. It was therefore obvious that knowledge gain could not be improved by elements that simply were

[1] This chapter is currently under preparation for submission as the journal article: Kelle, S., Klemke, R. & Specht, M.: Achievement Patterns applied on Life Science Content.

not prominent enough. Another observation was that the participants also had indicated that they lack the perception of look and feel of a game. This led us to conceptualize a learning scenario with more gamification elements, such as a badge reward system that would be *very difficult* to overlook. Early feedback drawn from a qualitative beta study pointed us at several points to iteratively address in the design of the prototype, with respect to user-centred design and user involved design. The results of the preliminary beta review study were promising: users were asked to state their opinion and impression of the badges, and make suggestions or give critique. The result was very positive. The users had fun "hunting" for badges as these were clearly perceived as reward. Another point taken into account was the change to a learning subject with a wider base of content than what was possible before in the domain of basic life support. We found the topic of nutrition to be a fitting domain because of an abundance of content available as well as being relevant to most people, regardless of demographic criteria.

7.2. Background

Achievement badges are a fundamental reward element found in all types of games. Especially in digital gaming, such elements are straightforward to use, because the interactive game logic of digital games make it possible that certain user interactions dynamically change the state of the game – and hence, for example, its visualization elements.

In this light, achievement badges are little more than a playful incarnation of status/awareness indicators. Glahn et al. (2007) suggest that such indicators are elements that give the user orientation in a complex learning environment by displaying contextual information. Effectively, game elements that mirror the achievement of users are the same thing, but they are conceptualized differently. To build such badge elements so they fit into a (learning) game context, game design patterns are the method of choice (Björk and Holopainen, 2004).

While in Björk and Holopainen's tome of game design patterns, there exists no ready-to-use pattern for the design of achievement badges directly, such can be made up from several different sub-elements, according to the different requirements of the respective context.

For example, one of first digital games using these elements dates back as far as 1987: Nethack (Raymond, 2003). In this single player adventure game, while everything is represented as ascii text symbols, a status display indicates relevant information on the progress in the game on various details (damage, armor quality, power, hunger, experience level, etc.). At the end of the game, when the player's character dies, the player receives a "tombstone" with game stats and type of death engraved (figure 7.1).

Figure 7.1.: A tombstone, "awarded" at the end of a round of Nethack.

More modern variants of such "achievement" patterns include in-game graphical representations that consolidate a certain combination of user-related game information into one specific goal. For example, in Microsoft's popular first person shooter game Halo^{TM}, an achievement badge is awarded each time after a certain amount of points have been accumulated in terms of performance in the game. The badges are visualized as army-style ribbons, corresponding to advancement in military rank (Thompson, 2007).

Coming back to the question on how to design achievement badges from several other game design patterns, the question is non-trivial but nevertheless straightforward: semantic decomposition.

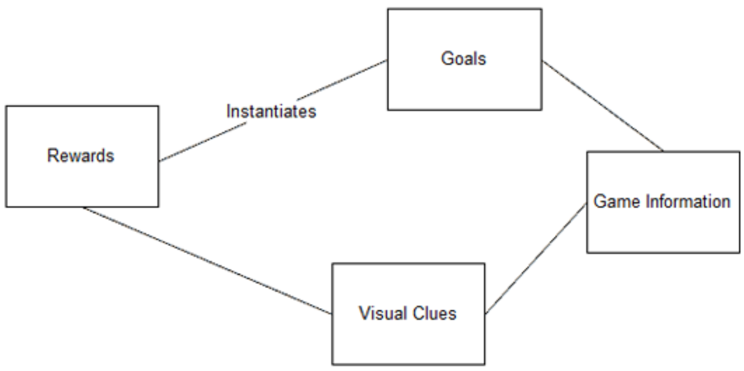

Figure 7.2.: Achievement Badges can for example be conceptualized from 4 different other game design patterns

While the expression "achievement badge" as such has no meaning without further contextualization (because – just by the term itself – we do not know the goal to achieve nor anything about the badge), a more refined definition helps: Achievement badges are rewards that form a partial goal inside the game, informing the player about in-game status and progress. Figure 7.2 illustrates the patterns that are used to make up this combinatory definition.

7.3. Design

To substantiate the game design, the mapping procedure described in our earlier work was employed (Kelle et al., 2011b). According to the taxonomies discussed in chapter 2, a combination of game patterns actually relates to a combination of pedagogical patterns, i.e. effects and educational functions. Therefore, the assumption drawn on a combination of the patterns is that the corresponding pedagogical functions can be achieved. Naturally, not each of the learning functions can be achieved in equal strength, but at least one main effect can be achieved by the main pattern.

Concerning the experimental design, one of the possible critique points of the previous experimentation was that the choice of the basic life support topic had some disadvantages. One point was that in order to maintain relevance to a general audience only a quite limited choice of material could be used, while at the same time there was the problem of previous knowledge interfering with the desired measurement of knowledge gain in a pre/post setup. Also, the results drawn from the eyetracking study in chapter 6, the visualization factor was problematic, because participant did not register the interface components related to the game patterns.

In order to get more exhaustive results, we wanted to explore a different domain for the application of patterns in a different game structure. Furthermore, the domain of nutrition provides a larger body of knowledge, due to the absence of strict standardization.

A further change from previous design is the employment of not just isolated game design patterns used to gamify existing content, but a more comprehensive and thus more game-like approach. With this, a change in experimental design concatenates. Instead of alternating between two isolated patterns yielding four different combinations (no patterns, either one pattern and two patterns applied), now we differentiated just between a control group (no pattern) and an experimental group (patterns applied).

Table 7.1.: Achievement patterns and their mapping on learning function, using the steps described in chapter 2. The descriptions are according to Björk and Holopainen (2004)

Pattern	Description	Taxonomy	Learning Function
Rewards	The player receives something perceived as positive, or is relieved of a negative effect, for completing goals in the game.	Mostly Gagné's taxonomy	Feedback and Evaluation
Goals	Goals are elements of a game that indicate progress and success while typically rewarding the player when reached.	Keller's ARCS model	Motivation
Visual Clues (1,20,3)	Clues are game elements that give the players information about how the goals of the game can be reached.	Keller's and Gagné's taxonomy	Attention
Game Information (6,21,1)	The goal of performing actions in the game in order to be able to receive information or make deductions.	Gagné's instructional event of "expectancy" (informing learners of the objective)	Expectation

7.4. Method

In the experimentation a user oriented method was used for preparation, by means of making use of a formative evaluation model in two steps. First, a qualitative pre-evaluation took place, with 9 participants of a high school class of 15–17 year old students (Belgian ASO level, to be qualified for higher education). In this preliminary ascertainment, only the gamified version of the artifact was used in order to capture the users' feedback and reactions with respect to user experience / usability. The input was then taken back to the lab to be used for enhancement of the prototype. In a second step, the main evaluation was carried out in another comparable high school, with 15–17 year old students (Dutch HAVO level, likewise to be qualified for higher education) of the same degree.

The Experiment was carried out in order to answer following research questions:

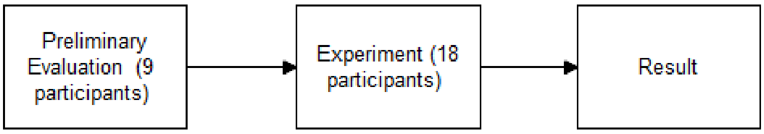

Figure 7.3.: The incremental process for designing the experimental artifact based on user input

(1) Will the knowledge gain of participants be significantly increased by the application of the gamified learning content in comparison with the control group's non-game-based treatment?

Hypothesis. Knowledge gain will increase for the test group treated with the achievement badge enhancement when compared with the control group.

(2) What are correlation effects and covariates, when looking at several demographic control variables drawn from the questionnaires?

Hypothesis. We expect that the effects of the treatment on the knowledge gain are independent of other variables like computer gaming experience.

(3) What impact can be measured for user experience in the different groups?

Hypothesis. The achievement badges have a positive impact on user experience, which we monitored in further dependent variables like perceived suspense and enjoyment in the treatment.

7.5. Implementation

In the implementation a the open source portal Liferay was used as basis for the application (Liferay, 2012). The Wiki function of the Liferay Server was used as starting point for modifications. A portlet was programmed that would monitor user interactions as well as display achievement badges. The portlet's function could be switched on or off by the admin in order to enable differentiation according to the experimental groups (test group vs. control group).

The portlet was named "badger" as it was generating the different achievement badges and monitoring the user interactions. In figure 7.4 the title screen is shown.

Upon entering the application, the users were directed to join the group to which they belonged (group 1 was the experimental/test group, group 2 was the control

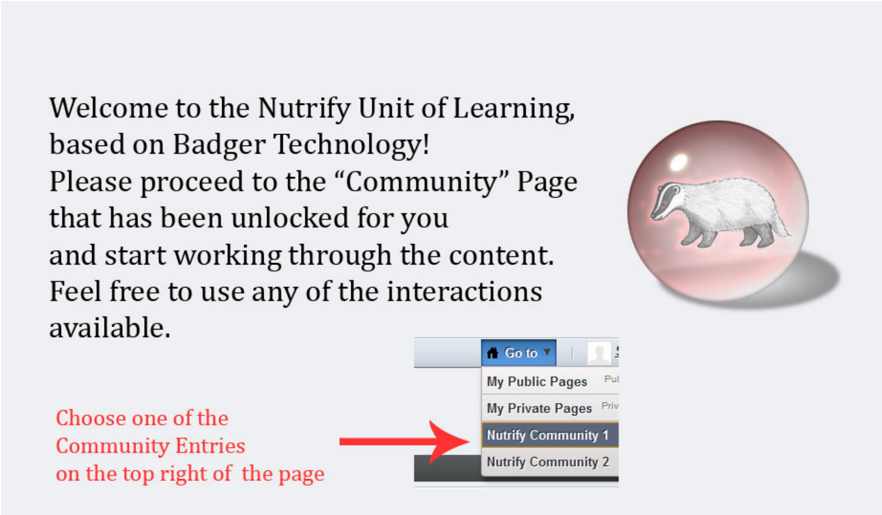

Figure 7.4.: Screenshot of the title screen just before entering the application

group), and then the actual application opened.

(a) Inactive Returner badge (b) Active Returner badge

Figure 7.5.: The active and inactive version of the Returner badge

The main visual element of the application were the achievement badges themselves. As shown in figure 7.5, the badges were designed as graphical elements indicating whether they had been achieved by changing from a grayscale version (figure 7.5(a)) to a colored version (figure 7.5(b)). In this example, the "Returner badge" is shown, reflecting whether users had revisited content they had encountered before.

In table 7.2 all of the badges that were implemented are listed, and their functions. The function was visible to the students by means small textual descriptions placed within and under the badges.

Table 7.2.: The badges and their functions. In order to maintain workable table size, pictograms of the badges are not included here (please see next figure).

Badge name	Function
Welcome badge	Activates on First page of content is opened.
10% done badge	Activates if 10% of content has been viewed
20% done badge	Activates if 20% of content has been viewed
30% done badge	Activates if 30% of content has been viewed
50% done badge	Activates if 50% of content has been viewed
90% done badge	Activates if 90% of content has been viewed
Returner badge	Activates if a page is revisited
Frequent returner badge	Activates if a page is revisited 5 times
Deep learner badge	Activates on sub-chapter structure is completed
Fast reader badge	Activates on number of pages read exceeds 5 in 2 minutes
Thorough reader badge	Activates on number of pages read below 5 in 2 minutes
First annotation badge	Activates on first annotation completed
Frequent annotation badge	Activates on 5th annotation
Badge name Deep thinker badge	Activates on User takes more than 2 minutes for an annotation
Self critical badge	Activates on User rates self assessment 2 or lower on a scale 1-5
Self confident badge	Activates on User rates self assessment 3 or higher on a scale 1-5
Cheating badge	Activates if user skips content inside a chapter or takes less than 20 seconds to view a page
Mastery badge	Activates when user completes especially detailed/difficult content

In the actual application, the visualization had to be implemented such that all of the badges could be viewed simultaneously while the content had to remain accessible in a comfortable way. In figure 7.6 it is visible how the content is displayed over one half of the screen whereas the badges portlet is using the other half of the screen.

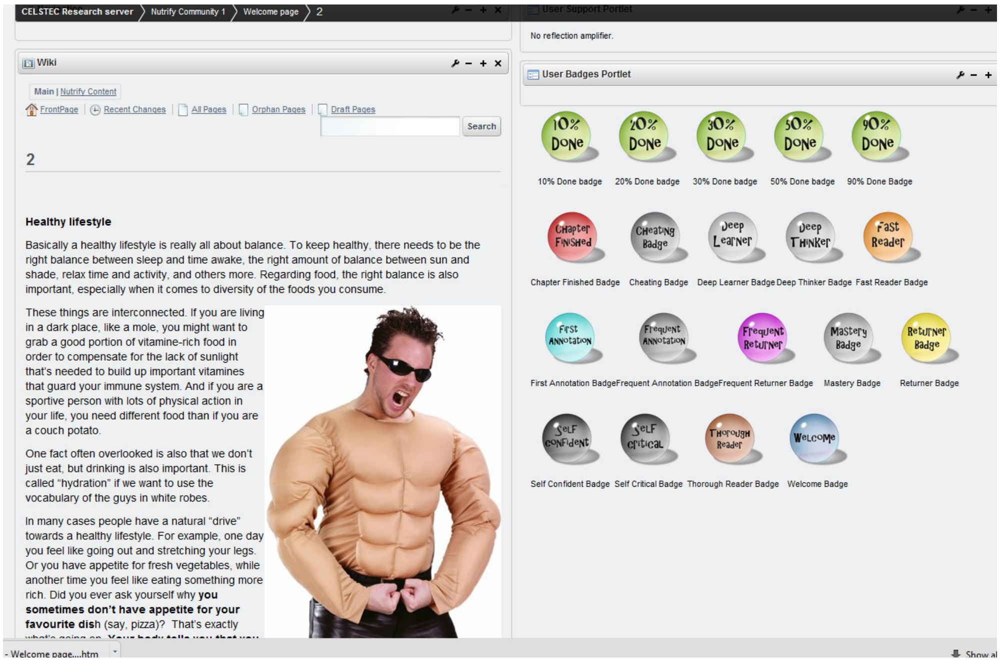

Figure 7.6.: Screenshot of the application screen with badge portlet switched on. When switched off, the badges were hidden and the content was visible using all of the space in the browser window.

7.6. Results

The results are decomposed into the preliminary ascertainment and the actual experiment. First, during the process of almost finishing the implementation phase it was possible to run the prototype at a belgian high school to gather qualitative feedback. The descriptive overview is given in table 7.3.

Table 7.3.: Descriptive Statistics of test results from the preliminary ascertainment

	N	Minimum	Maximum	Mean	Std. Deviation
PrevKnowl	9	2.00	4.00	2.7778	.66667
KnowGain	9	-4.00	2.00	.1111	1.96497
Excite	9	1.00	4.00	2.4444	1.13039
Stress	9	1.00	3.00	1.2222	.66667
Confuse	9	1.00	4.00	2.1111	1.05409
Enjoy	9	1.00	4.00	2.6667	.86603

From this result it can be seen that there was only little knowledge gain while the experiential variables of excitement, stress, confusion and enjoyment ranged also in the lower half (scales were 1=low to 5=high perception). This formative evaluation did obviously not produce significant insights, but nevertheless gave meaningful insight with respect to gathering qualitative feedback that could then be used for further refinement of the prototype. Here are some comments of the participants, which could be recorded in a free-text part of the post-test questionnaire:

> *"The badges were a distraction because i wanted to get them all but they were colourful"*
>
> *"The badges were fun, it's like an achievement and you want as many as possible, and the ones you don't get you try to get."*
>
> *"I don't think it's negative or positive it just shows you how much you have done."*
>
> *"I liked them! :) but I didn't manage to get them all! :'("*

This feedback could be interpreted twofold. On the one hand, the badges were making an appealing impression on the participants, contributing to both their excitement and enjoyment as stipulated in table 7.3. The badges, this time indeed were perceived by all of the participants as they were placed clearly recognizable and centrally in the user interface. On the other hand, it was mentioned that the badges also posed a certain distraction from the learning content, thus providing a possible adverse effect.

With this input, the following modifications were done for the main experiment:

- The size of the badges was reduced by 50 % such that they could all be watched in one glimpse without scrolling.
- The content was modified in appearance slightly, including images and a bigger font than before.

In the main experiment the results could be tested against our hypotheses. To get a first overview, in table 7.4 the descriptives are listed. The main dependent variable in question was the measure of "Knowledge Gain", which is listed in the table under the label "KnowGain". Other control variables were Previous Knowledge (listed as "PrevKnowl"), Excitement, Stress, Confusion and Enjoyment (listed accordingly).

As can be seen in the table, the users that were in the experimental group rated their previous knowledge slightly higher. In the Analyis part below we will therefore check the according covariate influence. Another aspect was that in the

Table 7.4.: Descriptive Statistics of main test results

Group		N	Minimum	Maximum	Mean	Std. Deviation
control	PrevKnowl	9	1.00	4.00	2.7778	.97183
	KnowGain	9	.00	5.00	2.1111	1.61589
	Excite	9	1.00	3.00	2.0000	.70711
	Stress	9	1.00	2.00	1.2222	.44096
	Confuse	9	1.00	4.00	2.4444	1.13039
	Enjoy	9	1.00	3.00	2.2222	.66667
exp	PrevKnowl	8	2.00	4.00	3.2500	.70711
	KnowGain	9	-2.00	4.00	1.2222	1.92209
	Excite	9	1.00	5.00	2.6667	1.22474
	Stress	9	1.00	3.00	1.4444	.72648
	Confuse	9	1.00	3.00	2.2222	.83333
	Enjoy	9	2.00	5.00	3.0000	1.00000

experimental group, on average, the levels of perceived Enjoyment and Excitement were higher than in the control group.

Hypothesis 1. Knowledge gain will increase for the test group treated with the achievement badge enhancement when compared with the control group.

Interestingly this hypothesis was not just refuted but the opposite happened. A significant knowledge gain could be measured in the control group, whereas the test group had only little, insignificant (yet positive) knowledge gain.

Already in the purely descriptive overview it is notable that the knowledge gain in the experimental group was lower than in the control group. According to a univariate between-subjects-analysis the results for the control group were $F(1, 9) = 15.362, p = .004$, which means the knowledge gain was significant at the 0.01 level. On the other hand, the result in the test group was not significant: $F(1, 9) = 3.639, p = .093$.

This clearly proves the opposite of the assumption made in the hypothesis. An explanation for what led to this unexpected result could be drawn from both system logs and the qualitative feedback that was likewisely recorded. Two users in the experimental group had both spent only 300 seconds on content consumption with an average knowledge gain of 0, while the rest of the users had spent an average of 643.2 seconds with an outcome of 2. These values indicate that a positive correlation exists between time spent on the content and knowledge gain. However, in the experimental group the time spent on content had to be shared with the time spent on dealing with the badges and other interaction. This was posing a distraction and thus explains why the control group had a stronger positive outcome (there, the whole duration of the experiment was used for content consumption, because that was the only thing available).

Free text feedback was given too, indicating the distractive potential of the badges:

> *"I like them."*
>
> *"In my opinion they were useless and demotivating, because when we had to end I wasn't even halfway there and those bubbles let me know that."*
>
> *"I don't know, it gave colour to the site."*
>
> *"i liked that you could see how far i was during the reading about nutrition."*
>
> *"They were too big and too distracting, but I guess that was the point."*

Hypothesis 2. We expect that the effects of the treatment on the knowledge gain are independent of other variables like previous knowledge.

In this case, the hypothesis could be verified, due to previous knowledge being of insignificant covariate effect in the control group ($F(1, 9) = .003, p = .983$) and in the test group ($F(1, 9) = 1.129, p = .399$).

Hypothesis 3. The achievement badges have a positive impact on user experience, which we monitored in further dependent variables like perceived suspense and enjoyment in the treatment.

As stated in our earlier work (Kelle et al., 2011b), the notion of flow is supported by a positive and engaging learning experience and contributes to a high level of perceptive ability. In order to achieve this momentum, a positive level of excitement and enjoyment is desirable.

For that reason, both the control variables excitement and enjoyment had been monitored in the post test. As reported in the descriptive overview in table 7.4, the excitement value is higher in the test group (2.66) than the control group (2.00), and the enjoyment value in the test group (3.00) is also higher than in the control group (2.22). However, no significant correlation between either enjoyment or excitement and knowledge gain could be measured, which may well be due to the relatively small number of participants in the study. In a test of covariate influence on the knowledge gain, also no significance threshold was reached.

Although not being statistically relevant, the observation was made that the factor of enjoyment was of even smaller covariate significance in both groups than the factor of excitement (see table 7.5). Another observation is that in the test group, the level of confusion had a relatively high impact, which supports the assertion of the distractive influence of the badges.

Table 7.5.: Main effects and significance of covariates

Group	Covariate	*F*	Sig.
Control	Excitememt	.258	.646
	Enjoyment	.015	.911
	Stress	.032	.869
	Confusion	.290	.627
Exp	Excitememt	1.459	.351
	Enjoyment	.004	.956
	Stress	.018	.906
	Confusion	2.600	.248

7.7. Discussion

The results of this study point at several issues that come with the visual distraction of users. Not only have we discovered that achievement badges have a big attention-drawing influence on users, but also that they have to be employed carefully in order to avoid distraction from learning content.

The major result that points at this circumstance is the refutation of hypothesis 1. In this case, the control group was far ahead of the test group in terms of knowledge gain. With respect to hypothesis 2, we found that the knowledge gain is independent of previous knowledge, which supports the overall effectivity of the measure. Hypothesis 3 yielded a mixed result, showing a slight tendency toward the benefit of enjoyment and excitement. Significance tests did, however, not sufficiently support this result.

Overall, this result can be explained by going back into psychology research. Eriksen and Hoffman (1973) have made the observation that "the identity of a distractor" matters in terms of being compatible or incompatible with the main subject of attention (in our case, the learning content). While there is arguably a great deal of compatibility of the achievement badges with the content, due to them mirroring the progress of the learning content, the incompatibility may be caused by their context insensitivity. A possible enhancement of the prototype could therefore be achievement badges that relate more explicitely to the content as such, for example by reflecting certain learning goals, such as a quick summary of the definition of caloric weight, during the respective learning stage.

The other aspect is that of visualization. In comparison to the previous study in chapter 6 it became apparent that the appearance (e.g. space consumed) of the game elements was dominating. While the timer used in the previous study was very small, the badges in this study consumed almost half the screen. The potential of game design patterns for learning is, therefore, highly dependent on practical questions like user interface design and not just the logic behind them.

Chapter 8.

General Discussion

8.1. Introduction

The results of this thesis have been reported in two main parts: A theoretical synthetic part (part I), and an experimental analytic part (part II). The exploratory approach taken in the experimental part, albeit incrementally designed on top of one another, explores several different scenarios covering a range of closely related, yet different approaches.

In this section [1], after a brief contemplation on cybernetic aspects, the experimental parts will be reviewed and interpreted how they, viewed in a combined way, support, extend or possibly conflict with the theories of the beginning part.

In a nutshell, the four experiments that have been carried out partly support the theoretic models introduced in part I, but partly also show their limitations: While the first two experiments show rather positive tendencies regarding both cognitive and metacognitive aspects of learning, the last two experiments stipulate the existence of design barriers that come into play when over- or under-steering the threshold of learner attention.

8.2. A cybernetic view on learning game design

With the general approach of designing games for learning we touch upon a possibly conflicting encounter of two systemic dimensions: learning and gaming. In an early (unpublished) attempt of structuring this research we differentiated between three different levels:

[1] This discussion is inspired by an unpublished paper: Kelle, S., Klemke, R. and Schmitz, B.: Towards Personal Game Learning Environments

- Learning how to play a game

- Use the game to explicitly reach a learning goal (i.e. the game goal and the learning goal are in line)

- Use the game to implicitly learn something else (i.e. the learning goal is hidden in the game)

According to Heylighen and Joslyn (2001), the field of cybernetics helps "describing [...] very different systems with the same concepts, and to look for isomorphisms between them.", in order to do this, concept structures that are needed for high level design are employed, such as "order, organization, complexity, structure, information, and control".

This notion very much complies with the same as we used for the mapping between educational components (i.e. learning functions) and game design patterns – two different systems we describe with similar concepts.

The three different levels noted above form a foundation of how to merge the two opposing concepts on an abstract level. While the first level (Learning how to play a game) is relatively self-contained, it is noteworthy that often a game-based approach brings with it a learning curve that is to be followed in order to master its mere operation. This can be easily observed when looking at completely recreational games that have no intended purpose of learning, other than the skill to acquire the competence level needed to perform well in order to advance and/or beat opponents. This, however, often bears the danger to demotivate players that are new to a game (Thomas and Macredie, 1994).

On the second level, in which games are used explicitly for a certain learning purpose, it is also possible to be explicit about the desired learning functions to be enhanced by the gamification applied. There is, however, the problem of substantiation. One game design pattern might match well with a certain learning function, but the context dependence provides a notion of imponderability. Not every game design pattern matches well with the same learning function if conditions are changed, for example to another context. Plus, what may make a certain design element seem important from the game designer's (or evaluator's) perspective, might indeed find the educationalist's disfavor, and vice versa.

Finally, on the third level, games are used to literally "trick" learners into approaching the intended learning goal. At this level the border between the learning and gaming perspective becomes very blurred, because any intervention that may monitor progress can give away the intended purpose and thus makes experimentation solely rely on tacit monitoring, which may provide ethical issues. (Oliver, 2003).

According to Umpleby and Dent (1999), from a second order cybernetics standpoint, different observation perspectives are contributing to different interpretation of experiments and their results. In our domain there are two sides – the game design and the education perspective. The frictions involved bear the hazard to lead to a possible mutual blockade of the two constructs, but possibly also to a mutual fertilization. This work has aspired to keep the two perspectives balanced, by both inquiring upon learning processes and knowledge gain as well as user experience and appreciation. The synthesis of this, therefore, is a result that may present a contribution both in terms of constructivism and realism.

8.3. A review of results

With the two sides of the coin in mind, the theoretical part of this thesis targets at bridging these two parts. In chapter 1, the basic idea of mapping game design patterns with educational objectives is introduced and how this concept could possibly be of advantage in a life-long learning context where users are in need of sustaining motivation of pursuing their learning task.

Chapter 2 elaborates this idea in more detail, getting to a more concrete level of explaining the core of this thesis by suggesting a method of how to achieve this mapping. The basic assumption is that learning functions serve as the education side of learning game design; game design patterns – on the other hand – serve as the game design side. The "glue" that binds these two concepts together comes in form of a choice of taxonomies that substantiate the individual mappings.

One of the questions chapter 3 tries to answer is how the more technical side can be supported by employing different existing standards drawn from the educational and the gaming side. The main result here is the model that stipulates two perspectives that are relevant to technically design learning games: either the design perspective is demanding to start from a learning perspective, making the gaming aspect a "slave" construct that is controlled by the learning process and enriching or "gamifying" the learning design. Or vice versa, the game design controls the learning process. A game designer may benefit from this model choice in terms of being able to assess which side is easier to start out from. This may depend on existing preparation work done or other circumstances that favour an initial design effort directed at one of the two perspectives.

In the experiments in part II, the main driver was to find practical insight into how these concepts may further illuminate and possibly verify the theories in part I. First of all, in a rather preliminary experiment (chapter 4) the goal was to use several game design patterns that are supporting ambient information channels in terms of visual clues and test their effectiveness in the real-life scenario of a small conference. Three different awareness types were targeted by the approach:

Social-, workspace- and task-awareness. These information channels made use of the "clues" game design pattern in the respective implementation modality. The results could be interpreted to the extent that task awareness was enhanced mostly by using the combined force of the different information channels. Although quantitatively not clearly significant, qualitative feedback supported that social interaction was positively influenced.

In the next experiment, a more traditional approach was taken, identifying clearly two different game design patterns that were carefully implemented on top of learning content, which was fit for a broad audience: Basic Life Support. The results showed that the combination of the two patterns (score and timer pattern) had partly significant results, especially in the subset of older participants of the study.

Based on this result we further enhanced the test prototype (chapter 6), introducing additional experimental effort with respect to further increasing the number of test subjects, system logfile evaluation, eye-tracking and retention testing. However, the results were not as positive this time due to the absence of any significance of knowledge gain. The age-relevance that came out of the previous study was not verified, but here the aspect of perceived suspense was forming a significant covariate with respect to positive knowledge gain. Also, the additional instrument of eye-tracking revealed that the visual clues as which the timer and score patterns were implemented were not prominent enough to draw the attention of the participants.

In a final experiment (chapter 7), a more prominent implementation of game elements was chosen, this time in a different scenario (high school classes, active monitoring quantitavely and qualitatively). The results, however, produced only very slightly positive outcome in terms of knowledge gain and user experience. The visual elements had distracted the particpants too much from the learning content in order to support the reaching of their learning goal, while still there was a positive (qualitative) resonance with respect to excitement and enjoyment.

8.4. Implications of this research

Although the modifications made in the last two experiments (chapter 6 and 7) can be regarded as enhancement in terms of analyst methodology, their actual application in the test scenarios yielded results that were not in accordance with the hypotheses suggesting an improvement of knowledge gain in comparison with the respective control groups. In total, the experiment in chapter 5 produced the most positive results. This supports the conjecture that there is a narrow corridor of productive user attention, outside of which the visual perception of participants is either over- or under-satisfied (figure 8.1).

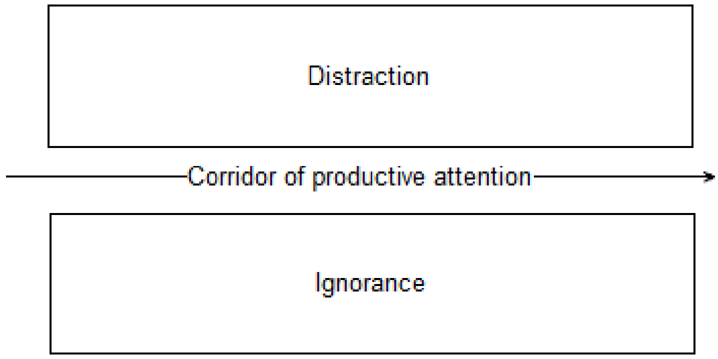

Figure 8.1.: The corridor of productive attention, inside which the users benefit from positive knowledge gain. The vertical axis may be interpreted as stimulus intensity.

An explanation for this observation can be found in the work of Yantis (1998): Visual stimuli have a positive effect when they have a close relation to the goal of the activity, and are in such sense compatible to this goal.

With this rather human-computer-interaction related insight, the role of game design patterns seemingly is reduced to purely their visual role in terms of user experience, indicating the importance of determining the right balance in user interface design.

Also, going deeper into cognitive science / educational psychology research, another aspect can be found that might explain these results: the notion of "Cognitive Load Theory". In the article by Tabbers et al. (2004), it was noted that multimedia cues given to learners were of beneficial nature in terms of learning gain, while audio-based cues had adverse and/or distracting effects. They explain this adverse effect with the overtaxing of learners' mental capacity to process multimodal information. It appears that a similar effect can happen in a gamified context when cues in the form of game elements are catching the learners' attention, thus flooding the learners' working memory and blocking the capacity to process relevant learning content (Kirschner, 2002) without leaving space for the cognitive load necessary to get closer to the learning goal.

However, other aspects that are more relevant to the designer's side are of equal concern. The Basic Life Support experiment in chapter 5 showed that a design process driven by the model suggested in chapter 3 worked in terms of providing both positive outcome in learning and gaming experience, when using the learning-process driven approach. The same was reported also in chapter 3 for the design process driven by the game design perspective (SPITKOM). Combining this observation with the possibility to successfully map learning functions with game design patterns the following implications come into reach:

- This concept can be used as a starting point for successful learning game design, inspiring designers to find meaningful combinations, balancing learning and gaming aspects.
- Due to the structured character of the approach, it is also possible to turn the concept upside-down and make use of the potential to use "reverse engineering", i.e. to analyze existing games and to determine which of their mechanisms and elements constitute the link between learning and gaming.
- When used for design, the concept should be used in a balanced way to make sure to avoid over- or under-satisfying the respective target audience's attention threshold.

There is still a possible critique point of using "standardized" methods for something creative and artistic like game creation in general. The constraint of being forced into schematic behaviour is indeed not what designers with some artistic aspirations could possibly hope for. However, if policy makers give these methods and design patterns a character of benevolent recommendation with a wide liberty of valid interpretation space, a positive perception may come into closer reach. Indeed, standards can also make design tools more accessible and lower entrance barriers, while the artistic interpretation of a designer remains untouched.

8.5. Limitations and future research

The field of game-based learning provides many challenges, and one of the main problems of research in this field is the aspect of transferability from one domain or context to another. Although this research has limited its range of inquiry to a quite small choice of contexts and domains even inside that limited exploration space the variations were of manifold nature. The most difficult challenge was to vary between the different studies to an extent that would not leave the incremental chain of design (one experiment building on the results of the previous one), but still explore additional perspectives horizontally. With the current status quo we can not deduct safely that the mapping of game design patterns with learning functions according to the procedure described in chapter 2 is the one method of making good learning games. There are still too many variables that need to be considered additionally: learning context, target audience, subject domain, technical barriers et cetera. One problem with our studies also was that we did not get to the point where the learners needed to start processing the feedback they got, and do more complex activities for learning. Also, closely related to feedback, monitoring has provided the challenge to clearly be related to the learning goals of the participants. If the context is missing or wrong, monitoring does not work.

This thesis and its concepts, however, are more meant to raise awareness of educationalists about game design perspectives and vice versa. The synthesis of the approach bears the potential for inhabitants of both sides to move closer to each other when they wish to find inspiration on the underlying principles of learning game design. Actually making good learning games then still requires a lot of work, talent, and some luck as well.

The future research in this field certainly has already commenced. During the work of this thesis many other scientists and practitioners were infected with the idea of making learning a game-like experience or making games a learning tool, supported by the technological advancements that are spurred by the arrival of new and tirelessly evolving technologies, especially in the mobile computing sector.

In addition to the "trends" already mentioned in chapter 1, future research in this field will have to deal with the following leads:

- Increased availability of mobile devices with high power and very large screen resolution, very likely soon to enable a breakthrough in augmented reality and voice recognition that is actually fit for the mass-market. Here, game design patterns for learning might be of interest to identify connections between learning functions and game elements that leverage the mobile learning paradigm.

- Lightweight concepts both regarding usability, hardware requirements (also power consumption, which is often overlooked) and cost effectiveness, which is a more general challenge in mobile learning.

- Breaking the frontiers of what is currently regarded as "gamifiable" in terms of learning content; for this, game design patterns for learning can serve as knowledge base to be extended with new insights and research results.

- Privacy and data protection issues, which may be identified by reverse engineering existing approaches (i.e. decomposing into patterns), especially regarding those that make use of social media.

List of Figures

List of Tables

References

(2009). 80 days project.

Adams, E. (2009). *Fundamentals of Game Design*. New Riders Press, 2 edition.

Agerbo, E. and Cornils, A. (1998). How to preserve the benefits of design patterns. In *ACM SIGPLAN Notices*, volume 33, pages 134–143.

Alexander, C. (1976). *A Pattern Language: Towns, Buildings, Construction*. Oxford University Press, New York.

Becker, K. (2005). How are games educational? learning theories embodied in games. *DiGRA, Vancouver, Canada*.

Becker, K. (2007). Instructional ethology: reverse engineering for serious design of educational games. In *Proceedings of the 2007 conference on Future Play*, pages 121–128.

Ben Zur, H. and Breznitz, S. J. (1981). The effect of time pressure on risky choice behavior. *Acta Psychologica*, 47(2):89–104.

Björk, S. and Holopainen, J. (2004). *Patterns in game design*. Charles River Media, Boston.

Bloom, B. (1956). *Taxonomy of Educational Objectives: Handbooks 1 to 3: The Cognitive, Affective and Psychomotor Domain*. London: Longmans Green.

Blorb (2012). Blorb: An IF resource collection format standard. http://www.eblong.com/zarf/blorb/.

Bopp, M. (2006). Didactic analysis of digital games and game-based learning. *Affective and Emotional Aspects of HumanComputer Interaction*, 1:8–37.

Börner, D. (2007). *Integration von Spiel-basierten Lernprogrammen in SCORM-konformen Lernumgebungen unter besonderer Beachtung des Multi-User Aspektes*. PhD thesis.

Boyle, T. (2003). Design principles for authoring dynamic, reusable learning objects. 19(1):46–58.

Breuer, J. S. and Bente, G. (2010). Why so serious? on the relation of serious games and learning. *Eludamos. Journal for Computer Game Culture*, 4(1):7–24.

Brown, J. S., Collins, A., and Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. *Knowing, learning, and instruction: Essays in honor of Robert Glaser*, page 487.

Brusk, J. and Björk, S. (2009). Gameplay design patterns for game dialogues. In *Breaking New Ground: Innovation in Games, Play, Practice and Theory: Proceedings of the 2009 Digital Games Research Association Conference, London. Brunel University.(Cited on page 21.)*.

Burghardt, G. (2005). The genesis of animal play. *Integrative and Comparative Biology*, 45(5):953–953.

Burgos, D., Moreno-Ger, P., Sierra, J. L., and Fernandez-Manjon, B. (2007). Authoring game-based adaptive units of learning with IMS learning design and e-Adventure. *International Journal of Learning Technology*, 3(3):252–268.

Butler, D. and Winne, P. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of educational research*, 65(3):245.

Cerulli, M., Chioccariello, A., Lemut, E., et al. (2007). A micoworld to implant a germ of probability.

Coffield, F. (2000). The necessity of informal learning.

Cooper, A. and Kraan, W. (2012). Assessing the business case for standards: Introduction for strategy planning and resourcing committees. http://www.jisc.ac.uk.

Crawford, C. (1984). *The art of computer game design*. Osborne/McGraw-Hill Berkeley, CA.

Cryengine3 (2012). Cryengine 3 web site. http://mycryengine.com/.

De Freitas, S. (2006). Learning in immersive worlds. *London: Joint Information Systems Committee*.

De Freitas, S. and Griffiths, M. (2008). The convergence of gaming practices with other media forms: what potential for learning? a review of the literature. *Learning, media and technology*, 33(1):11–20.

Del Blanco, A., Torrente, J., Moreno-Ger, P., and Fernández-Manjón, B. (2010a). Integrating adaptive games in Student-Centered virtual learning environments. *International Journal of Distance Education Technologies (IJDET)*, 8(3):1–15.

Del Blanco, A., Torrente, J., Moreno-Ger, P., and Fernández-Manjón, B. (2010b). Towards the generalization of Game-Based learning: Integrating educational video games in LAMS. In *Proceedings of the 2010 10th IEEE International Conference on Advanced Learning Technologies*, pages 644–648.

Denis, G. and Jouvelot, P. (2005). Motivation-driven educational game design: applying best practices to music education. In *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*, pages 462–465.

Dickey, M. D. (2007). Game design and learning: a conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development*, 55(3):253–273.

DirectX (2012). Where is the DirectX SDK? http://msdn.microsoft.com/en-us/library/windows/desktop/ee663275(v=vs.85).aspx.

Donikian, S. and Portugal, J. N. (2004). Writing interactive fiction scenarii with dramachina. *Technologies for Interactive Digital Storytelling and Entertainment*, pages 101–112.

Duval, E. (2004). Learning technology standardization: making sense of it all. *Computer Science and Information Systems*, 1(1):33–43.

Ebner, M. and Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education*, 49(3):873–890.

ECDL (2011). European computer driver's license. http://www.ecdl.de/.

Elektra (2009). Elektra project: Home. http://www.elektra-project.org/. Retrieved July 9, 2009.

Endsley, M. (2000). Theoretical underpinnings of situation awareness: A critical review. *Situation awareness analysis and measurement*, pages 3–32.

ERC (2011). ERC guidelines for resuscitation 2010 - article in motion. http://resuscitation-guidelines.articleinmotion.com/resource-center.

Ericsson, K. A. and Simon, H. A. (1980). Verbal reports as data. *Psychological review*, 87(3):215.

Eriksen, C. W. and Hoffman, J. E. (1973). The extent of processing of noise elements during selective encoding from visual displays. *Attention, Perception, & Psychophysics*, 14(1):155–160.

Farrell, J. and Saloner, G. (1985). Standardization, compatibility, and innovation. *The RAND Journal of Economics*, pages 70–83.

FLAR (2012). FLAR toolkit web site. http://goo.gl/vMvdj.

FLEX (2012). Adobe Flex web site. http://www.adobe.com/de/products/flex.html.

Foreman, J. (2004). Game-based learning: How to delight and instruct in the 21st century. 11.

Gagné, R. M. (1965). *The conditions of learning.* Holt, Rinehart and Winston, New York, NY.

Gamma, E. (1995). *Design patterns: elements of reusable object-oriented software.* Addison-Wesley Professional, Bosten, MA.

Garris, R., Ahlers, R., and Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & gaming*, 33(4):441–467.

Gee, J. P., Haves, E. R., Hayes, E., et al. (2010). Women and gaming: The sims and 21st century learning. *Women and gaming: The Sims and 21st century learning.*

Glahn, C. (2009). *Contextual support of social engagement and reflection on the Web.* PhD thesis, Open University of The Netherlands.

Glahn, C., Specht, M., and Koper, R. (2007). Smart indicators on learning interactions. In Duval, E., Klamma, R., and Wolpers, M., editors, *Creating New Learning Experiences on a Global Scale*, volume 4753 of *Lecture Notes in Computer Science*, pages 56–70. Springer Berlin / Heidelberg.

Grant, J. (2002). Learning needs assessment: assessing the need. *Bmj*, 324(7330):156–159.

Gredler, M. E. (1994). *Designing and evaluating games and simulations: A process approach.* Gulf Publishing Company.

Gredler, M. E. (2004). Games and simulations and their relationships to learning. *Handbook of research on educational communications and technology*, 2:571–581.

Grohé, M. (2009). Der Weg ist das Spiel. *GEE*, pages 58–61.

Grösser, M. (2007). Effective teaching: linking teaching to learning functions. *South African Journal of Education*, 27(1):37–52.

Gruber, M., Glahn, C., Specht, M., and Koper, R. (2010). Orchestrating learning using adaptive educational designs in IMS learning design. In *Sustaining TEL: From Innovation to Learning and Practice*, pages 123–138.

Gunter, G., Kenny, R., and Vick, E. (2006). A case for a formal design paradigm for serious games. *The Journal of the International Digital Media and Arts Association*, 3(1):93–105.

Gunter, G., Kenny, R., and Vick, E. (2008). Taking educational games seriously: using the RETAIN model to design endogenous fantasy into standalone educational games. *Educational Technology Research and Development*, 56(5):511–537.

GWT (2012). Google web toolkit web site. https://developers.google.com/web-toolkit/.

Harlen, W. and James, M. (1997). Assessment and learning: differences and relationships between formative and summative assessment. *Assessment in Education*, 4(3):365âĂŞ379.

Hart, I. (2001). Deschooling and the Web: Ivan Illich 30 Years On. *Educational Media International*, 38(2-3):69–76.

Hawes, A. (1996). Jungle gyms: The evolution of animal play. [Retrieved July 7, 2009].

Heinich, R., Molenda, M., Russell, J. D., and Smaldino, S. E. (2002). *Instructional media and technologies for learning*. New Jersey: Upper Saddle River.

Heylighen, F. and Joslyn, C. (2001). Cybernetics and second order cybernetics. *Encyclopedia of physical science & technology*, 4:155–170.

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., and Van de Weijer, J. (2011). Eye tracking: a comprehensive guide to methods and measures.

Huynh-Kim-Bang, B., Wisdom, J., and Labat, J. (2010). Design patterns in serious games: a blue print for combining fun and learning. *Project SE-SG*. available at http://seriousgames.lip6.fr/DesignPatterns/.

Illich, I. (1971). *Deschooling Society*. Harper & Row New York.

Inform7 (2012). Inform 7 home page. http://inform7.com/.

Johnson, L., Levine, A., Smith, R., and Smythe, T. (2009). The 2009 horizon report. *Austin, Texas: The New Media Consortium.*, 3.

Johnson, L., Smith, R., Willis, H., Levine, A., and Haywood, K. (2011). The 2011 horizon report. *The New Media Consortium, Austin, Texas*.

Kelle, S., Klemke, R., Gruber, M., and Specht, M. (2011a). Standardization of game based learning design. *Computational Science and Its Applications-ICCSA 2011*, pages 518–532.

Kelle, S., Klemke, R., and Specht, M. (2011b). Design patterns for learning games. *International Journal of Technology Enhanced Learning*, 3(6):555–569.

Kelle, S., Klemke, R., and Specht, M. (2012). Effects of game design patterns on basic-life-support content. Submitted to International Journal of Educational Technology and Society.

Kelle, S., Westera, W., Sigurðarson, S., and Specht, M. (2011c). Game based lifelong learning. In Magoulas, G. D., editor, *E-Infrastructures and Technologies for Lifelong Learning*, pages 337–349. IGI Global, Hershey, PA.

Keller, J. M. (1983). Motivational design of instruction. *Instructional design theories and models: An overview of their current status.*

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and higher education*, 8(1):13–24.

Kiili, K. (2007). Foundation for problem-based gaming. *British Journal of Educational Technology*, 38(3):394–404.

Kiili, K. (2011a). Kristian kiili's research blog. http://kiili.wordpress.com/.

Kiili, K. (2011b). Reflection walkthrough method: designing knowledge construction in learning games. In *In: Conolly, T. & Stansfield, M.(eds.) 2nd European Conference on Games Based Learning, hosted by the Universitat Oberta de Catalunya, Spain, 16-17 October, 2008.*

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and instruction*, 12(1):1–10.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*, volume 1. Prentice-Hall Englewood Cliffs, NJ.

Koole, M. L. (2009). A model for framing mobile learning. *Mobile Learning Transforming the delivery of education and training*, pages 25–47.

Krathwohl, D. R. (1964). The taxonomy of educational objectives: Its use in curriculum building. *Defining educational objectives*, pages 19–36.

Kreimeier, B. (2002). *The case for game design patterns.*

Kuntz, M. (1999). Teacher's guide. http://www.brainmeld.org/TeachingGuideLibrary/BrainMeld-SimCity3000-Kuntz.pdf.

LAMS (2011). LAMS: learning activity management system. http://www.lamsinternational.com/. Learning Activity Management System (LAMS) LAMS is a revolutionary new tool for designing, managing and delivering online collaborative learning activities.

Lankoski, P., Johansson, A., Karlsson, B., Björk, S., and Dell'Acqua, P. (2011). AI design for believable characters via gameplay design patterns. *Business, Technological, and Social Dimensions of Computer Games Edited By: Maria Cruz-Cunha (Ed.) Vitor Hugo Varvalho (Ed.) Paula Tavares (Ed.). IGI.*

Liferay (2012). Liferay Web Site. [Online; accessed 27-June-2012].

Livingstone, D. and Hollins, P. (2010). Virtual worlds, standards and interoperability. *International Journal of IT Standards and Standardization Research (IJITSR)*, 8(2):45–59.

Ludewig, M. and Bager, J. (2011). Gamification: Webanwendungen mit spielelementen aufpeppen. *C'T, Magazin für Computer-Technik.*

Lynn, M. (1991). Scarcity effects on value: A quantitative review of the commodity theory literature. *Psychology and Marketing*, 8(1):43–57.

Lyytinen, K. and Yoo, Y. (2002). Ubiquitous computing. *Communications of the ACM*, 45(12):63.

Mac an Airchinnigh, M. (2010). Life after digitization, deschooling society 2010 & beyond. *Deschooling Society*, pages 19–20.

Maddock, S. (1999). *Challenging women: gender, culture and organization.* Sage Publications Ltd.

Malo, S., Diener, H., Hambach, S., and Jungius-Str, J. (2008). Entwicklung von computerbasierten lernspielen im spannungsfeld zwischen aufwand und anspruch. *GI-Edition-Lecture Notes in Informatics (LNI)-Proceedings*, 132:365–376.

Maule, A. J. and Edland, A. C. (1997). The effects of time pressure on human judgment and decision making. *Decision making: Cognitive models and explanations*, pages 189–204.

Minović, M., Milovanovć, M., Starcevic, D., and Jovanovć, M. (2010). Learning objects in educational games. *International Journal of Technology Enhanced Learning*, 2(4):336–346.

Minović, M., Milovanović, M., Starcevic, D., and Jovanović, M. (2009). Knowledge modeling for educational games. *Visioning and Engineering the Knowledge Society. A Web Science Perspective*, pages 156–165.

Mor, Y., Mellar, H., Pachler, N., and Daly, C. (2011). Formative e-assessment: case stories, design patterns and future scenarios. pages 199–219.

Mor, Y., Winters, N., Cerulli, M., and Björk, S. (2006). Literature review on the use of games in mathematical learning, part i: Design. *Report of the Learning Patterns for the Design and Deployment of Mathematical Games project.*

Mor, Y., Winters, N., Pratt, D., and Björk, S. (2007). Tools for developing design patterns for mathematical computer games. In *Proceedings of the Game in Action Conference, Göteborg, Sweden.*

Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., and Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior*, 24(6):2530–2540.

Moreno-Ger, P., Burgos, D., Sierra, J., and Manjón, B. (2007). A game-based adaptive unit of learning with ims learning design and. *Creating New Learning Experiences on a Global Scale*, pages 247–261.

Mory, E. (2004). Feedback research revisited. *Handbook of research on educational communications and technology*, pages 745–783.

Nadolski, R. J., Hummel, H. G., Van Den Brink, H. J., Hoefakker, R. E., Slootmaker, A., Kurvers, H. J., and Storm, J. (2008). EMERGO: a methodology and toolkit for developing serious games in higher education. *Simulation & Gaming*, 39(3):338–352.

Najjar, J., Derntl, M., Klobucar, T., Simon, B., Totschnig, M., Grant, S., and Pawlowski, J. (2010). A data model for describing and exchanging personal achieved learning outcomes (PALO). *International Journal of IT Standards and Standardization Research (IJITSR)*, 8(2):87–104.

Nelson, G. (2011). Afterword: Five years later. In Jackson-Mead, K. and Wheeler, J. R., editors, *Interactive Fiction Theory Reader*, pages 189–202.

Ogata, H. (2009). Assisting awareness in ubiquitous learning. *Proceedings of the IADIS Mobile Learning*, pages 21–27.

Ogata, H. and Yano, Y. (2004). Context-aware support for computer-supported ubiquitous learning. In *Wireless and Mobile Technologies in Education, 2004. Proceedings. the 2nd IEEE International Workshop on*, pages 27–34.

Oliver, P. (2003). *The student's guide to research ethics.* Open University Press Maidenhead.

O'Neil, H. F., Wainess, R., and Baker, E. L. (2005). Classification of learning outcomes: Evidence from the computer games literature. *The Cirriculum Journal*, 16(4):455–474.

OReilly, T. (2007). What is web 2.0: Design patterns and business models for the next generation of software.

Peña-López, I. (2007). Web 2.0 and education seminar (V): Ambjörn Naeve: The Human Semantic Web – Increasing the Global Organizational Performance of Humanity Inc. *ICTlogy, review of ICT4D*, 49.

Peters, O. and Keegan, D. (1994). *Otto Peters on distance education: The industrialization of teaching and learning.* Psychology Press.

Pivec, M. and Dziabenko, O. (2004). Game-based learning in universities and lifelong learning: "UniGame: social skills and knowledge training" game concept. *Journal of Universal Computer Science*, 10(1):14–26.

Plass, J. L. and Homer, B. D. (2009). Educational game design pattern candidates. *Journal of Research in Science Teaching*, 44(1):133–153.

Pratt, D. D., Winters, N., Cerulli, M., and Leemkuil, H. (2009). A patterns approach to connecting the design and deployment of mathematical games and simulations. *Technology-Enhanced Learning*, pages 215–232.

Project, K. (2011). Kaleidoscope. http://www.noe-kaleidoscope.org/telearc/.

Project, P. P. (2010). The pedagogical patterns project. http://www.pedagogicalpatterns.org/.

Ratan, R. and Ritterfeld, U. (2009). Classifying serious games. In Ritterfeld, U., Cody, M. J., and Vorderer, P., editors, *Serious games: mechanisms and effects*, pages 10–24. Taylor & Francis.

Raymond, E. S. (2003). *A Guide to the Mazes of Menace: Guidebook for NetHack.*

Retalis, S., Georgiakakis, P., and Dimitriadis, Y. (2006). Eliciting design patterns for e-learning systems. *Computer Science Education*, 16(2):105–118.

Richards, G. (2005). Designing educational games. In Koper, R. and Tattersall, C., editors, *Learning Design*, pages 227–237. Springer Berlin Heidelberg New York.

Rieber, L. P. (2005). Multimedia learning in games, simulations, and microworlds. *The Cambridge handbook of multimedia learning*, pages 549–567.

Ritterfeld, U., Cody, M. J., and Vorderer, P. (2009). *Serious games: Mechanisms and effects.* Taylor & Francis.

Robinson, P. (1998). Strategies for designing instruction in web-based computer conferencing environments. *University of Maryland College Park.*

Roy, A., Evans, C., Sharples, M., and Benford, S. (2009). Mobile game based learning for peer educators of males having sex with males community in india. http://www.iamlearn.org/public/mlearn2009/sessions.asp.html.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional science*, 18(2):119âĂŞ144.

Salen, K. and Zimmerman, E. (2003). *Rules of Play: Game Design Fundamentals*. The MIT Press.

Sawyer, B. and Smith, P. (2009). Serious games taxonomy. In *Slides from the Serious Games Summit at the Game Developers Conference*, San Francisco, CA.

Schank, R. C. and Cleary, C. (1995). *Engines for education*. Lawrence Erlbaum.

Schell, J. (2008). *The Art of Game Design: A book of lenses*. Morgan Kaufmann.

Schilit, B., Adams, N., and Want, R. (1994). Context-aware computing applications. In *Mobile Computing Systems and Applications, 1994. WMCSA 1994. First Workshop on*, pages 85–90.

Schmitz, B. (2012). Supporting knowledge construction with mobile learning games. http://goo.gl/68XpH.

Schmitz, B., Czauderna, A., Klemke, R., and Specht, M. (2011). Game based learning for computer science education. In *Computer Science Educaiton Research Conference*, pages 81–86.

Serious Games Initiative (2012). Serious games initiative. http://www.seriousgames.org/.

Shuell, T. J. and Moran, K. A. (1994). Learning theories: historical overview and trends. *The international encyclopaedia of education*, 2:3340–3345.

Shute, V., Rieber, L., and Van Eck, R. (2011). Games... and... learning. *Trends and issues in instructional design and technology*, 3.

Shute, V., Ventura, M., Bauer, M., and Zapata-Rivera, D. (2009). Melding the power of serious games and embedded assessment to monitor and foster learning. *Serious games: Mechanisms and effects*, pages 295–321.

Sigurðarson, S. E. (2008). Moodle.org: Personal glossary & quizzer. http://bit.ly/OFvypY. Retrieved December 8, 2009.

Simon, B. and Pulkkinen, M. (2010). *ICOPER Reference Model Specification Draft*.

Sloep, P. (2002). Learning technology standardization. http://dspace.learningnetworks.org/handle/1820/119. Preprint from dspace.ou.nl.

Smaldino, S. E., Lowther, D. L., and Russell, J. D. (2011). *Instructional Technology and Media for Learning*. Allyn & Bacon, 10 edition.

Specht, M. (2009). *Learning in a Technology Enhanced World: Context in Ubiquitous Learning Support.* Open University of The Netherlands, Heerlen, The Netherlands. Inaugural Address, September 11, 2009.

Squire, K. (2005). *Game-based learning: Present and future state of the field.* Masie Center e-Learning Consortium.

Stenros, J., Holopainen, J., Waern, A., Montola, M., and Ollila, E. (2011). Narrative friction in alternate reality games: Design insights from conspiracy for good. In *Proceedings of DiGRA 2011 Conference: Think Design Play*, Utrecht, The Netherlands. DiGRA.

Stenzel, H. (2011). Motion Capturing unter Verwendung der Microsoft Kinect. http://www.gm.fh-koeln.de/hstl/Dokumente/PraxisprojektGebauer2012-01.pdf.

Susi, T., Johannesson, M., and Backlund, P. (2007). Serious Games – An Overview. *Skövde: University of Skövde (Technical Report HS-IKI-TR-07-001).*

Syvanen, A., Beale, R., Sharples, M., Ahonen, M., and Lonsdale, P. (2005). Supporting pervasive learning environments: adaptability and context awareness in mobile learning. In *Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on*, pages 3–6.

Tabbers, H. K., Martens, R. L., and Van Merriënboer, J. J. G. (2004). Multimedia instructions and cognitive load theory: Effects of modality and cueing. *British Journal of Educational Psychology*, 74(1):71–81.

Ternier, S., Massart, D., Totschnig, M., Klerkx, J., and Duval, E. (2010). The simple publishing interface (SPI). *D-Lib Magazine*, 16(9/10).

Thomas, P. and Macredie, R. (1994). Games and the design of Human–Computer interfaces. *Innovations in Education & Training International*, 31(2):134–142.

Thomas, P., Yessad, A., and Labat, J. (2011). Petri nets and ontologies: Tools for the learning player assessment in serious games. In *Advanced Learning Technologies (ICALT), 2011 11th IEEE International Conference on*, pages 415–419.

Thompson, C. (2007). Halo 3: How microsoft labs invented a new science of play. *Wired Magazine*, 15(9).

Traxler, J. (2009). Current state of mobile learning1. *Mobile learning*, page 9.

Umpleby, S. A. and Dent, E. B. (1999). The origins and purposes of several traditions in systems theory and cybernetics. *Cybernetics & Systems*, 30(2):79–103.

Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE review*, 41(2):16.

Verpoorten, D., Westera, W., and Specht, M. (2010). A classification framework of techniques for amplifying student's reflection in e-learning courses. *Journal of Interactive Learning Research*, 21(4).

Vision (2012). Havok vision engine. http://www.trinigy.net/products/vision-engine.

Wang, S. and Koohang, A. (2008). Ontology of learning objects repository for pedagogical knowledge sharing. *Interdisciplinary Journal of Knowledge and Learning Objects*, 4:1–12.

Weiser, M. (1991). The computer for the 21st century. *Scientific American*, 265(3):94–104.

Westera, W., Nadolski, R. J., Hummel, H. G. K., and Wopereis, I. (2008). Serious games for higher education: a framework for reducing design complexity. *Journal of Computer Assisted Learning*, 24(5):420–432.

Wilson, S., Liber, O., Johnson, M., Beauvoir, P., Sharples, P., and Milligan, C. (2009). Personal learning environments: Challenging the dominant design of educational systems. *Journal of e-Learning and Knowledge Society-English Version*, 3(2).

Winters, N. and Mor, Y. (2009). Dealing with abstraction: Case study generalisation as a method for eliciting design patterns. *Computers in Human Behavior*, 25(5):1079–1088.

XNA (2012). XNA developer center. http://msdn.microsoft.com/en-us/centrum-xna.aspx.

Yantis, S. (1998). Control of visual attention. In Pashler, H. E., editor, *Attention*, volume 1, pages 223–256. Psychology Press, Hove, East Sussex, UK.

Zimmerman, B. (1990). Self-regulated learning and academic achievement: An overview. *Educational psychologist*, 25(1):3–17.

Appendix A.

Methods and Materials

A.1. Materials for the experiment described in chapter 4

A.1.1. Rules of the Mr. X Game

The rules given to the participants were:

- The game is played in several rounds. At the beginning of each round one of the participants is selected as Mr. X by random. Mind you, it could be yourself, or he/she could be sitting next to you!

- Periodically you will receive three hints about the wanted person. These hints will describe Mr. X in person as well as his/her social and professional life. Watch out for these information clues as they will be sent to you via email OR publicly displayed.

- Your task is then to try to find out something about your fellow participants by getting acquainted with them and discussing who could be the currently wanted person.

- If you have a suspicion, use a computer and go to http://medialabexp.appspot.com/voting.html. If you have a built-in webcam you can scan the marker on your badge to identify yourself, alternatively you can use your email address. To make your vote simply click on the name of the person you suspect.

- You can change your mind anytime, so feel free to make another vote whenever you want. There is no limit on the number of votes, as long as the current round is open.

- The round is closed once more than 50% of all participants voted for the right person OR the wanted person is not identified by the participants after giving you five times three hints.
- Finally, at the end of each round, Mr. X is revealed and you will get points depending on your latest vote.
- At the end of each round every participant will get points, including Mr. X!
- If you did not vote at all you get -100 points. If you voted for the right person you get +100 points. Respectively you get -50 points if you voted for the wrong person. Mr. X will get additional +200 bonus points if he/she is not identified before the round is closed.

A.1.2. Algorithm for scoring

```

public static void calcScores(){
    if(vData.getVoterID() == pServer.getId()){
            voted = true;
            /**
             * if the voter votes correctly, increase
                score by 100
             */
    if(vData.getVoteeID() == rData.getMrxID()){
            int newScore = pServer.getScore() + 100;
            pServer.setScore(newScore);
    }else{
            /**
             * if the voter votes incorrectly, decrease
                score by 50
             */
            Int newScore = pServer.getScore() - 50;
            pServer.setScore(newScore);
            }
    if(pServer.getId() == rData.getMrxID()){
            pServer.setMrx(true);
            /**
             * if Mr. X successfully escapes, increase
                his/her score by 200
```

```
                */
    if(VoteManager.checkVotes(false) == false){
            int newScore = pServer.getScore() + 200;
        pServer.setScore(newScore);
    }
            /**
             * if a participant doesn't vote at all,
                decrease score by 100
             */
    if(!voted){
        int newScore = pServer.getScore() - 100;
        pServer.setScore(newScore);
        }
    }
```

A.1.3. Questionnaire as source for clues displayed

This questionnaire was done to ascertain profile information to determine characteristic features of the personality and habits of participants. Answers could be given in free text.

1. What do you prefer in the coffee breaks? (Juice, Tea, Coffee, other)
2. Which drinks do you prefer in the evening? (Beer etc.)
3. What kind of wintersport activity do you prefer? (Skiing, Sledding etc.)
4. If you were reborn as an animal, what would it be?
5. Where did you go to primary school?
6. What is the name of the university you studied at?
7. What was your favourite band when you were 16?
8. How many legs does your pet have?
9. Which term describes your professional attitude best?
10. What was the last movie you saw in cinema?
11. What is your favorite region for holidays?

12. What was the last book you read?
13. In which city were you born?
14. What was the last concert you visited?
15. How many siblings do you have?
16. What kind of weather do you prefer?
17. In which country do you live?
18. How do you go to work? (Car, cycling, etc.)
19. What is your favorite color?
20. Who is your professional (work-related) idol?
21. What do you normally do on sundays?
22. What is your favorite English word?

A.2. Materials for the experiment described in chapter 5

A.2.1. Questionnaire on Basic Life Support experimental prototype

Thank you for participating in this experiment.

In this experiment you will be asked for some information about yourself; then you will also be kindly requested to play a round of a first-response-to-emergency situation game, and finally to continue to answer some more questions about your experience and results in the game.

Please answer all questions in this questionnaire, then follow the link to the game and play it to the end, finally answer the survey at the end of the game (it's a much shorter one than this), and make sure to answer all questions there.

Submit your ID in that end questionnaire (this is the email-address you are using to log in here). Time: overall, 20 minutes are estimated for participation. I set the limit to 1 hour in case it's more convenient to take more time...

Background info: The experiment is run within a PhD project on Game-Based Learning at CELSTEC institute, The Netherlands. The domain of first aid and basic life support appears as good target for testing specifics about the serious game approach.

Disclaimer. The material presented in the serious game prototype - although chosen with care - does not claim to have any medical validity. I or my institute do not take responsibility if something goes wrong when you get involved in a real emergency. The prototype is used for this experiment only and not meant for public use other than made available to participants in the study.

Part 1: Please answer some preliminary questions.

In the following questionnaire, the knowledge related questions such as "What is CPR" were all "multiple choice" with only one possible correct answer.

1. Please enter you email address (in a few weeks I will very briefly get back in touch with results).

2. Where are you from (example: "London, UK")

3. Where are you currently based (example: "Shanghai, China", skip this if same as above)

4. What is your gender? (Male, Female)

5. What is your age?

6. Which of the following best describes your highest achieved education level? (no formal education level, high school degree, some university courses or college degree, university degree, some doctoral courses, doctorate)

7. How much medical knowledge (and/or experience) do you have about first aid and basic life support?

8. Did you ever attend a first aid course, and if yes how many times?

9. What were the reasons for you to take (a) first aid course(s)? (if you haven't taken any, please skip this)

   I needed it for the driver's license

I did it voluntarily because of personal interest.

It's required for my job.

I did it because I have been in an emergency situation myself, or somebody who is close to me

I did it because in my close environment someone is old or sick and might require help some day. I needed to be prepared for it.

I did it because my friends were also doing it.

Other:

10. Do you think you will take a(nother) first aid course?

11. Why are you (or would you be) planning to do a(nother) first aid course? (Please answer this question even if you answered the previous one negatively, in that case hypothetically: "if you would be going to take a first aid course, what would be your motivation?". Check all that apply.)

    I need it for the driver's license

    Because of personal interest.

    It's required for my job.

    Because I have been in an emergency situation myself, or somebody who is close to me

    Private circumstances may require so (e.g. in my family someone is old or sick and might require help some day.)

    My friends are talking about doing it.

    Other:

12. How would you rate your general computer literacy?

13. How would you rate your experience with computer (and/or video-) games?

14. How current is that experience?

15. How would you react if you are involved in a traffic accident in which it looks like somebody got seriously injured (but you yourself are okay)? (Just reply intuitively with your most likely reaction about what you would do as very first thing.)

16. How would you react if you encounter an unconscious person inside a building? (Just reply intuitively with your most likely reaction about what you would do as very first thing.)

17. How would you react if you encounter an unconscious person in the open (outside)? (Just reply intuitively with your most likely reaction about what you would do as very first thing.)

18. There is a victim that appears to be unconscious. For some reason It turns out that you are the person that needs to try to "revive" the victim. What to do first? (Just reply intuitively with your most likely reaction about what you would do as very first thing.)

19. What is CPR?

20. What is an AED?

21. You are about to give Heart Massage and Rescue Breaths to a victim. How to do that?

Part 2: The serious game prototype.

After answering above questions, please go to http://tiny.cc/7xfr1 and play the game to the end. Just follow the instructions, it should be almost self-explaining. (The page should open in a new browser window). When you arrive at the end of the game you will see a button "click here to go to survey" which takes you to a new page where you can open a survey page. Please make sure to fill out that survey (max. 5 minutes) to complete the task.

By the way, in order to play the game, you need a recent version of the most popular browsers (we tested it on the latest firefox, internet explorer and chrome), plus a relatively quick broadband internet connection.

A.2.2. Post test questionnaire

The knowledge related questions, such as "What is CPR?" were multiple choice questions with only one correct answer

1. Did you fully understand how the game works?

2. Did you enjoy playing the game?

3. You encounter a person lying on the ground, what do you do? (several choices of which 1 is correct)

4. What is CPR?

5. You are about to give Heart Massage and Rescue Breaths to a victim. How to do that?

6. How would you rate the suspense factor in the game How many points did you reach?

7. Do you have the impression that you know more about first aid and basic life support than before?

8. Do you have the impression that now you are more confident what to do than before if there should be an emergency situation you encounter?

9. About the "timer" element in the game: How did you perceive the pressure created by this?

10. About the "score" element in the game: How did you perceive it?

11. How would you react if you are involved in a traffic accident in which it looks like somebody got seriously injured (but you yourself are okay)?

12. How would you react if you encounter an unconscious person inside a building?

13. How would you react if you encounter an unconscious person in the open? here is a victim that appears to be unconscious. For some reason It turns out that you are the person that needs to try to "revive" the victim. What to do first?

14. What is an AED?

A.3. Materials for the experiment described in chapter 6

A.3.1. Descrition for participants of the study

Thank you for participating in this experiment.

The participation is simple. You just open the link below and play an experimental "game" like quiz about first aid and basic life support. You don't need to do anything special, just answer all questions in the beginning and the end, and try to answer to the "quiz" questions intuitively.

Important:

Please first make sure you have a screen resolultion 1024x768 or higher. A modern screen should have that.
Please complete the following steps:

1. Submit your email address in this page.
2. Follow the link to the game and answer all questions there (the questionnaires in the beginning and the end as well as the quiz questions)
3. Please don't click the reload button in your browser. Let it load and play the quiz only once. In the end of the game, make sure to click the "post results" button, where you should submit the same email address you provided here.
4. In the end there will also be a question if you want to to be contacted via email about the result of the experiment and with some info on a possible follow up questionnaire. This means I will send you ONE email, and that's it. Of course all information you submit here is confidential and will not be passed to any 3rd party, strictly following the Personal Data Protection Act of The Netherlands.
5. Time: overall, 15 minutes are estimated for this experiment (5 minutes to read this description and 10 minutes for the actual participation). However, I set the limit to 1 hour to leave plenty of time just in case.

Background info: The experiment is run within a PhD project on Game-Based Learning at CELSTEC institute, The Netherlands. The domain of first aid and basic life support appears as good target for testing specifics about the serious game approach.

Disclaimer. The material presented in the serious game prototype - although chosen with care - does not claim to have any medical validity. I or my institute do not take responsibility if something goes wrong when you get involved in a real emergency. The prototype is used for this experiment only and not meant for public use other than made available to participants in the study.

Requirements to participate. You need an internet connection, obviously, the faster your connection the faster things load. You also best should maximize your browser window. The minimum resolution required is 1024*768 pixels. Also, Adobe Flash is required. It doesn't matter what browser you have, as long as you have a recent version of Adobe Flash. The game roughly requires 2.5 MB of data volume, so double check if you are using an internet connection that has a limitation of data volume.

Part 1: Your email address, please.

Please enter you email address

Part 2: Ready? You are good to go. Click the link below and play the game!

Please go to http://145.20.132.16/bls2.swf and play the game to the end. You can leave this window open, the game will open a different browser tab. Finally don't forget to come back here and submit this form. That's all.

A.3.2. Questionnaires and prototype

Remark: The questionnaires (pre and post) were hard-coded into the prototype. They were not different from the questionnaires quoted in the previous appendix.

A.4. Materials for the experiment described in chapter 7

A.4.1. Pretest for formative study in Mol, Belgium

The knowledge related questions, such as "What is hydration" were multiple choice questions with only one correct answer

1. Please enter your name.

2. Please enter your email address.

3. What is your age?

4. Are you vegetarian?

   No, actually the opposite. I think that meat should be in every meal.

   No. I eat meat whenever it suits me.

   No but I don't eat certain types of meat (for example for religious reasons)

   No but I would prefer to be a vegetarian.

   Yes, but I make exceptions sometimes

   Yes, but I eat fish

   Yes

   Yes, by the way, I am vegan

5. Are you on currently on a diet?

6. What are Macronutrients?

7. What are fibres?

8. What is hydration?

9. What are trans fats?
10. What are proteins made of?
11. What are carbohydrates?
12. What are calories?
13. What is a diet?
14. What's the tricky thing about active lifestyle?
15. A fact about vegetarianism
16. What is fasting
17. What is Anorexia
18. On a scale 1 (low) to 5 (high) please rate your previous knowledge on nutrition

A.4.2. Post test questionnaire for formative study in Mol, Belgium

The knowledge related questions, such as "What is hydration" were multiple choice questions with only one correct answer

1. Please enter your name.
2. Please enter your email address
3. What are Macronutrients?
4. What are fibres?
5. What is hydration?
6. What are trans fats?
7. What are proteins made of?

8. What are carbohydrates?

9. What are calories?

10. What is a diet?

11. What's the tricky thing about active lifestyle

12. A fact about vegetarianism

13. What is fasting

14. What is Anorexia

15. Please rank on a scale 1 (low) to 5 (high)... [Did you feel excitement or suspense during this activity?]

16. Please rank on a scale 1 (low) to 5 (high)... [Did you feel stress/pressure during this activity?]

17. Please rank on a scale 1 (low) to 5 (high)... [Were you confused by the user interface?]

18. Please rank on a scale 1 (low) to 5 (high)... [Did you enjoy the activity?]

19. Please enter further comments, suggestions or critique here

20. About the badges/bubbles, please make comments (oral instructions were given how to rate usability)

A.4.3. Pre-test of experiment run in Echt, Netherlands

The knowledge related questions, such as "What is hydration" were multiple choice questions with only one correct answer

1. Please enter your name.

2. Please enter your email address

3. What is your age?

4. Are you vegetarian?

5. Are you on currently on a diet?
6. What are Macronutrients?
7. What are fibres? What is hydration?
8. What are trans fats?
9. What are proteins made of?
10. What are carbohydrates?
11. What are calories?
12. What is a diet?
13. What's the tricky thing about active lifestyle
14. A fact about vegetarianism
15. What is fasting
16. What is Anorexia
17. On a scale 1 (low) to 5 (high) please rate your previous knowledge on nutrition

A.4.4. Post-test of experiment run in Echt, Netherlands

The knowledge related questions, such as "What is hydration" were multiple choice questions with only one correct answer

1. Please enter your name.
2. Please enter your email address
3. What is your age?
4. Are you vegetarian?
5. Please tell us some more..

6. Are you on currently on a diet?
7. What are Macronutrients?
8. What are fibres?
9. What is hydration?
10. What are trans fats?
11. What are proteins made of?
12. What are carbohydrates? What are calories?
13. What is a diet?
14. Please, enter your login name here
15. What's the tricky thing about active lifestyle
16. A fact about vegetarianism
17. What is fasting
18. What is Anorexia
19. Please rank on a scale 1 (low) to 5 (high)... [Did you feel excitement or suspense during this activity?]
20. Please rank on a scale 1 (low) to 5 (high)... [Did you feel stress/pressure during this activity?]
21. Please rank on a scale 1 (low) to 5 (high)... [Were you confused by the user interface?]
22. Please rank on a scale 1 (low) to 5 (high)... [Did you enjoy the activity?]
23. Please enter further comments, suggestions or critique here About the badges/bubbles (in case you were in the group that had them)

A.4.5. Code listing for calculations of reward badges behaviour

```


    /**
     * This method calculates the state of the badges and returns a list of
     * badgeId = url.
     *
     * The suffix is -bw for inactive badges and an empty string for active
     * ones.
     *
     * The jsp page appends .png to the url returned.
     *
     */
    public SortedMap<String, String> getBadgeSuffix(PortletRequest request) {
        if (badges.size() == 0) {
            getBadges(request);
        }

        ThemeDisplay themeDisplay = (ThemeDisplay) request
                .getAttribute(WebKeys.THEME_DISPLAY);
        long userId = themeDisplay.getUserId();

        SortedMap<String, String> suffixes = new TreeMap<String, String>();

        for (Entry<String, Boolean> e : getEnabledBadges(request, userId)
                .entrySet()) {
            suffixes.put(e.getKey(), e.getValue() ? "" : "-bw");
        }

        return suffixes;
    }


    /**
```

```
     * This method calulates the state fo the badges and
        returns an list of
     * badgeId = enabled booleans.
     *
     * The calcuation is done for a particular user in
       the group obtained by the
     * portlet request/ themedisplay.
     *
     * @param request
     * @param userId
     *            The userId to calculate the badges for
       .
     * @return a list of badgeId=enabled.
     */
    public SortedMap<String, Boolean> getEnabledBadges(
        PortletRequest request,
            long userId) {
        Boolean active = false;

        ThemeDisplay themeDisplay = (ThemeDisplay)
          request
                .getAttribute(WebKeys.THEME_DISPLAY);
        long groupId = themeDisplay.getScopeGroupId();

        // badge base name = enabled|disabled
        SortedMap<String, Boolean> enabledBadges = new
          TreeMap<String, Boolean>();

        for (Entry<String, String> badge : badges.
          entrySet()) {
            enabledBadges.put(badge.getKey(), false);
        }

        try {

            // ///////////////////////////////
            // 1) Count Page Visits
            // ///////////////////////////////

            List<ActivityEntry> activityEntries =
              ActivityEntryLocalServiceUtil
                   .findByUserAndGroup(userId, groupId)
                     ;

```

```
            // WikiId(classPK)=Count
            Map<Long, Integer> pageVisits = new HashMap<
               Long, Integer>();

            int visitedPages = 0;

            for (int i = 0; i < activityEntries.size();
               i++) {
                long key = activityEntries.get(i).
                   getClassPK();

                // Count page views per WikiPage
                if (activityEntries.get(i).getActivityId
                   () == UserActivity_WebKeys.
                   VIEW_WIKIPAGE_ACTION) {
                    if (pageVisits.containsKey(key)) {
                        pageVisits.put(key, pageVisits.
                           get(key) + 1);
                    } else {
                        pageVisits.put(key, 1);
                    }

                    visitedPages++;
                }
            }

            // ///////////////////////////////
            // 2) Count Annotations / Notes
            // ///////////////////////////////

            // identifies a note).

            // WikiId(classPK)=Count
            Map<Long, Integer> annotationCounter = new
               HashMap<Long, Integer>();

            // Total number of Notes
            int annotationCount = 0;

            for (int i = 0; i < activityEntries.size();
               i++) {
                long key = activityEntries.get(i).
                   getClassPK();

```

```
            // Count annotations per WikiPage
            if (activityEntries.get(i).getActivityId
                () == UserActivity_WebKeys.
                END_NOTES_ACTION) {
                if (annotationCounter.containsKey(
                    key)) {
                    annotationCounter.put(key,
                            annotationCounter.get(
                                key) + 1);
                } else {
                    annotationCounter.put(key, 1);
                }
                annotationCount++;
            }
        }

        // ///////////////////////////////
        // 3) Get and Count Wiki Pages
        // ///////////////////////////////

        // Title = WikiPage
        SortedMap<String, WikiPage> pages =
            ActivityEntryLocalServiceUtil
                .getWikiPages(request);

        // The number of wiki pages.
        int pagecount = pages.size();

        // ///////////////////////////////
        // 3) Get Chapters and Count Visits.
        // ///////////////////////////////

        // ChapterNo=Number of pages per chapter
        Map<Integer, Integer> chapterPagesCounter =
            new HashMap<Integer, Integer>();

        // ChapterNo=Number of visited pages per
            chapter (multiple hits
        // count)
        Map<Integer, Integer> chaptervisitCounter =
            new HashMap<Integer, Integer>();

        // ChapterNo=Completed
```

```java
        Map<Integer, Completion> chaptersCompleted = new HashMap<Integer, Completion>();

        // List<Long> chaptervisitedPages = new ArrayList<Long>();

        for (Entry<String, WikiPage> page : pages.entrySet()) {
            Matcher matcher = pattern.matcher(page.getKey());
            if (matcher.find()) {
                try {
                    Integer chapter = Integer.parseInt(matcher.group());

                    System.out.println(chapter + "=" + page.getKey() + " ["
                            + page.getValue().getPageId() + "]");

                    if (!chapterPagesCounter.containsKey(chapter)) {
                        chapterPagesCounter.put(chapter, 0);
                    }

                    if (!chaptervisitCounter.containsKey(chapter)) {
                        chaptervisitCounter.put(chapter, 0);
                    }

                    if (!chaptersCompleted.containsKey(chapter)) {
                        chaptersCompleted.put(chapter,
                                Completion.notstarted);
                    }

                    // if (!chaptervisitedPages.contains(page.getValue()
                    // .getPrimaryKey())) {
```

```
                        // chaptervisitedPages.add(new Long(page.getValue()
                        // .getPrimaryKey()));
                        // }

                        chapterPagesCounter.put(chapter,
                                chapterPagesCounter.get(chapter) + 1);

                        long pageid = page.getValue().getPageId();

                        for (ActivityEntry ae : activityEntries) {
                            if (ae.getActivityId() == UserActivity_WebKeys.VIEW_WIKIPAGE_ACTION
                                    && ae.getClassPK() == pageid) {
                                chaptervisitCounter.put(chapter,
                                        chaptervisitCounter.get(chapter) + 1);
                            }
                        }

                    } catch (NumberFormatException e) {
                        // Nothing
                    }
                }
            }

            // ////////////////////////////////
            // 4) Check visited pages per chapter
            // ////////////////////////////////

            for (Integer chapter : chaptersCompleted.keySet()) {

                Boolean started = false;
                Boolean complete = true;

```

```
                for (Entry<String, WikiPage> page :
                   pages.entrySet()) {
                    Integer chap = titleToChapter(page.
                       getKey());

                    if (chapter.equals(chap)) {

                        // check activities for a match
                        Boolean found = false;
                        for (int i = 0; i <
                           activityEntries.size(); i++)
                           {
                            if (page.getValue().
                               getPageId() ==
                               activityEntries
                                   .get(i).getClassPK()
                                      ) {
                                started = true;
                                found = true;
                                break;
                            }
                        }

                        if (!found) {
                            complete = false;
                        }
                    }
                }

                // Update Status
                if (started) {
                    if (complete) {
                        chaptersCompleted.put(chapter,
                           Completion.completed);
                    } else {
                        chaptersCompleted.put(chapter,
                           Completion.started);
                    }
                }
            }

            // /////////////////////////////////
            // 5) Get Mastery Scores
            // /////////////////////////////////
```

```

            // Minimum Score on any page
            Double minScore = Double.MAX_VALUE;

            // Maximum Score on any page
            Double maxScore = Double.MIN_VALUE;

            for (Entry<String, WikiPage> page : pages.
               entrySet()) {
                try {
                    RatingsEntry ratingsEntry =
                       RatingsEntryLocalServiceUtil
                            .getEntry(userId, WikiPage.
                               class.getName(), page
                                    .getValue().
                                       getPrimaryKey());

                    minScore = Math.min(minScore,
                       ratingsEntry.getScore());
                    maxScore = Math.max(maxScore,
                       ratingsEntry.getScore());
                } catch (PortalException e) {
                    // Harmless: No RatingsEntry exists
                       with the key
                    // {userId=10169, classNameId=10129,
                        classPK=10508}
                    // _log.error(e.getMessage());
                }
            }

            // ///////////////////////////////
            // 6) Get Time spend on individual Notes
            // ///////////////////////////////

            // max # of sec taken for a note.
            long maxNoteTime = 0;

            for (int i = 0; i < activityEntries.size();
               i++) {
                ActivityEntry ae = activityEntries.get(i
                   );
                long key = ae.getClassPK();

                // Count page views per WikiPage
```

```
                if (ae.getActivityId() ==
                    UserActivity_WebKeys.
                    START_NOTES_ACTION) {
                    for (int j = i + 1; j <
                        activityEntries.size(); j++) {
                        ActivityEntry aee =
                            activityEntries.get(j);
                        if (key != aee.getClassPK()) {
                            break;
                        }
                        if (aee.getActivityId() ==
                            UserActivity_WebKeys.
                            END_NOTES_ACTION) {
                            maxNoteTime = Math.max(
                                maxNoteTime, (aee
                                    .getCreateDate().
                                        getTime() - ae
                                    .getCreateDate().
                                        getTime()) /
                                        1000);
                        }

                        visitedPages++;
                    }
                }
            }
```

Appendix B.

Summary

In this PhD project, a theoretical model of mapping game design patterns onto learning/teaching functions has been examined. In four studies, specific game design patterns have been used to “gamify” learning content, and positive effects in knowledge gain and user experience could be monitored when beneficial conditions were met. The domains targeted all belonged to the life-long-learning context, i.e medical topics like first aid and life science scenarios, as well as a social learning game scenario.

In part I, spotlight is on assumptions derived from relevant theories. Chapter 1 introduces the field of learning games, possible contexts and problem sources, as well as the notion of design patterns that can be used for the creation of learning games. This is exemplarily done with particular focus on the life-long learning context which poses the speficic challenge of self-motivation to the learner, and as such forms an interesting field for learning games.

The mentioned design patterns for learning are then discussed in more detail in chapter 2. The chapter gives detailed overview on relevant subject literature, explains the concept of game design patterns and pedagogical patterns, and lays out the synthesis thereof: design patterns for learning games. The way this synthesis is achieved is by connecting game design patterns to so-called "‘learning functions"’ via a set of pedagogical taxonomies. This procedure is reproducible, as it partly depends on metrical properties of the patterns involved as well as semantic overlap between the components. Additionally, the procedure has been tested with several experts in instructional technology, in order to verify this reproducibility.

Next, in chapter 3, principles are presented with respect to standardization of game-based learning content and design procedures. The European ICOPER project’s results are leveraged for the use of learning game design. While the project as such has been more directed towards the conceptualization of a technical infrastructure that harvests resources of different format to be used for e-learning solutions, the underlying architecture poses procedures that can be used for a finding good entry points into the design of a learning game, while making use of e-learning standards. Two different perspectives are presented and exempli-

fied with working prototypes of learning games: First, there is the perspective of starting the design process from the game design perspective, employing several e-learning standards to serve as content injector for the prototype. Second, the design process is started from the learning perspective, with game design elements being fed into an e-learning framework. The resulting design model opens the design process for learning games for both game designers and instructionalists alike.

In part II, several experiments are presented. The first experiment (chapter 4) is a rather small scale formative study that has been carried out seizing the opportunity of having a seminar like week of academic presentations and workshops in Innsbruck. During that week several people encountered who were not acquainted yet, and a game-based approach was used for stimulating “social learning”, i.e. finding out about persons and getting to know them more easily. The results showed that the combined power of the different information channels (and respective patterns) had the most notable effect on the intended outcome of the social learning process.

While the game design patterns examined here were more related to ubiquitous information awareness, in the next experiment (chapter 5) specific patterns were clearly isolated and formed actual elements in a rather classical game scenario: the timer and score pattern. With the setup being more controlled it was possible to find out how these patterns influenced different effects in learning outcome and user experience. The results were promising, like before, when the full treatment with both patterns was applied. However, a covariate influence of age of the participants was detected – it turned out that older participants were more receptive to the treatment.

Another experiment (chapter 6) with same basic design was carried out to re-evaluate the findings of the experiment before. Also, additional methods for monitoring were used, such as for example an eye tracker that precisely monitored user interaction. The result here was adding some critical insights, i.e. that learners were easily missing certain game-based stimuli if these were not presented prominently enough in the user interface. The age influence of the previous experiment, however, could not be reproduced.

Picking up on the findings of the previous experiment, an approach implementing more prominent game elements was applied in the final experiment (chapter 7). This was leading to distraction of the participants, while beneficial effects could be measured with respect to user experience.

The synthesis of these findings is presented in chapter 8, also making the connection to cybernetic concepts that hold true when principles from two juxtaposed sides (gaming and learning) meet and begin to form something new. In sum, the bottom line of this thesis is that the approach of matching game design patterns with learning functions bears the potential of aiding the design for games in the life-long learning context, when user-centered design principles are met in a very balanced way. With respect to cognitive load theory, game elements have to be administered in a very careful yet stimulating way in order to support learning processes, as well as a good user experience. With the design approach that keeps track of learning goals while simultaneously applying gamification to learning content, the overall goals of transparency, reproducibility and lowering initial design barriers come into closer reach.

Appendix C.

Samenvatting

In dit proefschrift is een theoretisch model onderzocht voor het afbeelden van game design patterns (i.e. game ontwerppatronen) op functies van leren en onderwijzen. In vier studies zijn specifieke game design patterns gebruikt om leerinhouden te verrijken (i.e., gamification van leerinhouden). Er werden positieve effecten gevonden voor kennisverwerving en gebruikerservaring, wanneer aan bepaalde voorwaarden werd voldaan. De domeinen waarop de aandacht werd gericht behoorden allen tot de context van leven lang leren, dat wil zeggen: medische onderwerpen, zoals scenario's voor eerste hulp en biowetenschappen, alsmede een game scenario voor sociaal leren.

In deel I ligt de nadruk op de veronderstellingen over de effecten en de afbeeldingen die zijn afgeleid van relevante leertheorieën. Hoofdstuk 1 introduceert het thema van educatieve games (i.e., learning games), mogelijke contexten en oorzaken van problemen, evenals het idee dat ontwerppatronen (i.e. design patterns) gebruikt kunnen worden voor het creëren van educatieve games. Dit wordt gedaan met een bijzondere nadruk op leven lang leren, wat een specifieke uitdaging vormt voor de zelfwerkzaamheid van de lerende, en als zodanig een interessant gebied vormt voor educatieve games.

De genoemde ontwerppatronen voor leren worden vervolgens meer gedetailleerd besproken in hoofdstuk 2. Het hoofdstuk geeft een gedetailleerd overzicht van relevante literatuur over het onderwerp, legt het concept uit van game ontwerppatronen en pedagogische patronen, en verklaart de synthese daarvan: ontwerppatronen voor educatieve games. De manier waarop deze synthese wordt bereikt, is door het verbinden van game ontwerppatronen met de zogenaamde "leerfuncties" via een reeks van pedagogische taxonomieën. Deze procedure is reproduceerbaar, omdat ze gedeeltelijk afhankelijk is van de metrische eigenschappen van de desbetreffende patronen, alsook van een semantische overlap tussen de componenten. Om deze reproduceerbaarheid te controleren is daarnaast de procedure gevalideerd door diverse deskundigen in ICT en onderwijs.

Vervolgens worden in hoofdstuk 3 de beginselen gepresenteerd met betrekking

tot de standaardisatie van de inhoud van educatieve games en diens ontwerpprocedures. De resultaten van het Europese ICOPER project worden ingezet ten behoeve van educatief game ontwerp (i.e. learning game design). Hoewel het project als zodanig meer is gericht op de conceptualisering van een technische infrastructuur die bronnen van verschillende technische formats vergaart voor e-learning oplossingen, verschaft de onderliggende architectuur procedures die gebruikt kunnen worden voor het vinden van goede startpunten bij het ontwerp van een educatieve game, met gebruikmaking van e-learning standaarden. Twee verschillende perspectieven worden gepresenteerd en toegelicht met werkende prototypes van educatieve games: ten eerste is er het perspectief van het starten van het ontwerpproces vanuit het game ontwerpperspectief, met gebruikmaking van een aantal e-learning standaarden die dienen als injector van de inhoud voor het prototype. Ten tweede wordt het ontwerpproces gestart vanuit het perspectief van leren, met game ontwerpelementen die worden toegevoerd aan een raamwerk van e-learning. Het daaruit voortkomende ontwerpmodel maakt het ontwerpproces voor educatieve games toegankelijk voor zowel de game ontwerpers alsook voor deskundigen op het gebied van ICT en onderwijs.

In deel II worden verschillende experimenten gepresenteerd. Het eerste experiment (hoofdstuk 4) is een vrij kleinschalige formatieve studie die werd uitgevoerd, gebruik makend van academische presentaties en workshops tijdens een seminar-achtige week, die werd georganiseerd in Innsbruck. Tijdens die week ontmoetten een aantal mensen elkaar voor de eerste keer en om het "sociaal leren" te stimuleren werd een op games gebaseerde benadering gebruikt, in dit geval om iets te weten te komen over personen en om ze gemakkelijker te leren kennen. De resultaten toonden aan dat de gecombineerde kracht van de verschillende informatiekanalen (en bijbehorende patronen) de meest opmerkelijke invloed had op het beoogde resultaat van het sociale leerproces.

Terwijl de hier onderzochte game ontwerppatronen meer gerelateerd waren aan alomtegenwoordig informatiebewustzijn, waren in het volgende experiment (hoofdstuk 5) specifieke patronen duidelijk geïsoleerd en vormden feitelijke elementen in een vrij klassiek game scenario: het tijdpatroon en het score-patroon. Met een meer gecontroleerde opzet was het mogelijk om erachter te komen hoe deze patronen verschillende effecten in het leerresultaat en de gebruikerservaring beïnvloedden als beide patronen werden toegepast. Er werd echter een mogelijk voorspelbare variabele invloed van de leeftijd van de deelnemers geconstateerd - het bleek dat oudere deelnemers meer ontvankelijk waren voor de aanpak.

Een ander experiment (hoofdstuk 6) werd met dezelfde onderzoeksopzet uitgevoerd om de bevindingen van het voorgaande experiment opnieuw te bezien. Ook zijn aanvullende methoden voor observatie gebruikt, zoals bijvoorbeeld een eye tracker om de interactie van de gebruiker nauwkeurig te observeren. Door het gebruik van de eye tracker was het mogelijk om diverse kritische ontwerp issues te identificeren, namelijk dat de lerenden eenvoudig bepaalde game-gebaseerde prikkels misten als deze niet prominent genoeg gepresenteerd werden in de gebruikersinterface. De leeftijdsinvloed van het vorige experiment kon echter niet worden gereproduceerd.

Voortbouwend op de bevindingen van het vorige experiment, werd een aanpak om prominentere game-elementen te implementeren toegepast in het laatste experiment (hoofdstuk 7). Dit leidde tot distractie van de deelnemers, terwijl gunstige effecten konden worden gemeten met betrekking tot gebruikerservaring.

De synthese van deze bevindingen wordt gepresenteerd in hoofdstuk 8, ook het maken van de verbinding met cybernetische concepten die gelden wanneer de beginselen van twee naast elkaar gelegen begrippen (gaming en leren) samenkomen en iets nieuws beginnen te vormen. Kortom, waar het uiteindelijk om gaat in dit proefschrift is dat de aanpak van het combineren van game ontwerppatronen met functies van leren het potentieel heeft om het ontwerp van games in de context van leven lang leren te ondersteunen, als ontwerpprincipes die gebruikers centraal stellen op een evenwichtige manier worden bereikt. Met betrekking tot de cognitieve belastingtheorie moeten, behalve een goede gebruikerservaring, game elementen op een zeer zorgvuldige en stimulerende manier worden toegepast om leerprocessen te ondersteunen. Met de ontwerpbenadering die zowel aandacht heeft voor de leerdoelen en tegelijkertijd "gamification" toepast op leerinhoud, komen de algemene doelstellingen van transparantie, reproduceerbaarheid van motiverende effecten van "gamification" en het verlagen van aanvankelijke barrières op het gebied van ontwerp dichterbij.

Appendix D.

Curriculum Vitae

Sebastian Kelle is currently holding a project position at the headquarter of Stuttgart Media University, building up a new center of higher education didactics. Before, he finished his PhD project as Research assistant at The Center for Learning Sciences and Technologies (CELSTEC) at the Open University in the Netherlands. There, he has been doing research that deals with the meaningful design of Digital Learning Games for use in higher and vocational education.

His research ranges from a broader perspective of learning game design (mapping learning concepts with game design patterns) down to the narrower scope of applying augmented reality and mobile technology to game based learning scenarios. He has been involved with a number of projects on the European level: ICOPER (Standardization of E-learning technologies), GRAPPLE (Adaptive Systems), as well as member in the advisory board of the EU ROLE project (Responsive Open Learning Environments). He is also a long term member of the ACM. He graduated from Freiburg University with a Master's degree in Computer Science and has been working for KPMG, Siemens and Vienna University of Economics before his PhD at CELSTEC. In his new role at Stuttgart Media University, he continues to collaborate in the field of international TEL research, while also more engaged in "classic" teaching and advisory.

D.1. Publications

dotLRN and Second Life, OpenACS and .LRN Spring Conference , Vienna, 27.4.2007

Creating a Prolearn Academy in Secondlife/SecondLife and Educational Practices, Fréjus, 30.5.2007

Sebastian Kelle, Raquel M.Crespo GarcÃŋa: Usability and Acessibility in Web 3D

(INTERACT 2007, Rio de Janeiro)

Pasquale Del Vecchio, Sebastian Kelle & Nouha Taifi: Customer Knowledge Management and Web 2.0 (9th IBIMA 2008, Marrakech)

Marcela C. Revilla & Sebastian Kelle: Knowledge Spillovers: The Virtual Generation, Volume 2, number 2, Communications of the IBIMA, 2008, pages 10-14

Johnscher, P., Kelle, S. & Sigurðarson, S. E. (2008, June 19). Acceptance of TEL, Factors for Success and Failure. PROLEARN Summerschool on Technology Enhanced Learning 2008.

Klaus Hammermüller, Phillip Pointner & Sebastian Kelle: Benefits and Limitations of using Virtual Worlds for Language Learning (IMCL 2009), Amman, Jordan.

Sebastian Kelle, Wim Westera & Marcus Specht (2009): Exploring Game Design Patterns for Learning. DSPACE

Sebastian Kelle, Steinn E. Sigurðarson, Wim Westera & Marcus Specht (2010): Game-Based Life-Long Learning. In George D. Magoulas (Ed.), E-Infrastructures and Technologies for Lifelong Learning: Next Generation Environments. Hershey, PA: IGI Global.

Kelle, S., Börner, D., Kalz, M. & Specht, M. (2010). Ambient Displays and Game Design Patterns. In M. Wolpers, P. A. Kirschner, M. Scheffel, S. Lindstädt & V. Dimitrova (Eds.), Sustaining TEL: From Innovation to Learning and Practice, Proceedings of EC-TEL 2010 (pp. 512–517). LNCS 6383. Berlin, Heidelberg & New York: Springer.

Kelle, S., Börner, D., Kalz, M., Specht, M. & Glahn, C. (2010). Ambient Displays and Game Design Patterns for Social Learning. In B. Chang, T. Hirashima & H. Ogata (Eds.), Joint Proceedings of the Work-in-Progress Poster and Invited Young Researcher Symposium for the 18th International Conference on Computers in Education (pp. 47–50). November, 29 – December, 3, 2010, Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Kelle, S., Klemke, R., Gruber, M. & Specht, M. (2011). Standardization of Game Based Learning Design. In B. Murgante, O. Gervasi, A. Iglesias, D. Taniar & B. O. Apduphan (Eds.), Computational Science and Its Applications - ICCSA 2011 (pp. 518-532). LNCS 6785 Berlin, Heidelberg & New York: Springer.

Kelle, S., Klemke, R. & Specht, M. (2011). Design Patterns for Learning Games. International Journal of Technology Enhanced Learning, Vol 3 No. 6 (pp. 555-569)

Geneva: Inderscience

Kelle, S., Klemke, R. & Specht, M. (2012). Effects of game design patterns on basic life support training content. Accepted for publication at International Journal of Educational Technology and Society.

Kelle, S., Jarodzka, H., Klemke, R. & Specht, M. (2012). In-depth analysis of Timer and Score Patterns applied on BLS Content. Submitted to Computers & Education Journal.

Appendix E.

SIKS Dissertation Series

The complete list of dissertations carried out under the auspices of SIKS, the Dutch Research School for Information and Knowledge Systems from 1998 on can be found at `http://www.siks.nl/dissertations.php`

2012

2012-40	Agus Gunawan (UvT) Information Access for SMEs in Indonesia
2012-39	Hassan Fatemi (UT) title of the book: Risk-aware design of value and coordination networks
2012-38	Selmar Smit (VU) Parameter Tuning and Scientific Testing in Evolutionary Algorithms
2012-37	Agnes Nakakawa (RUN) A Collaboration Process for Enterprise Architecture Creation
2012-36	Denis Ssebugwawo (RUN) Analysis and Evaluation of Collaborative Modeling Processes
2012-35	Evert Haasdijk (VU)

	Never Too Old To Learn – On-line Evolution of Controllers in Swarm- and Modular Robotics
2012-34	Pavol Jancura (RUN) Evolutionary analysis in PPI networks and applications
2012-33	Rory Sie (OUN) Coalitions in Cooperation Networks (COCOON)
2012-32	Wietske Visser (TUD) Qualitative multi-criteria preference representation and reasoning
2012-31	Emily Bagarukayo (RUN) A Learning by Construction Approach for Higher Order Cognitive Skills Improvement, Building Capacity and Infrastructure
2012-30	Alina Pommeranz (TUD) Designing Human-Centered Systems for Reflective Decision Making
2012-29	Almer Tigelaar (UT) Peer-to-Peer Information Retrieval
2012-28	Nancy Pascall (UvT) Engendering Technology Empowering Women
2012-27	Hayrettin Gürkök (UT) Mind the Sheep! User Experience Evaluation & Brain-Computer Interface Games
2012-26	Emile de Maat (UVA) Making Sense of Legal Text
2012-25	Silja Eckartz (UT) Managing the Business Case Development in Inter-Organizational IT Projects: A Methodology and its Application
2012-24	Laurens van der Werff (UT) Evaluation of Noisy Transcripts for Spoken Document Retrieval
2012-23	Christian Muehl (UT) Toward Affective Brain-Computer Interfaces: Exploring the Neurophysiology of Affect during Human Media Interaction
2012-22	Thijs Vis (UvT) Intelligence, politie en veiligheidsdienst: verenigbare grootheden?
2012-21	Roberto Cornacchia (TUD) Querying Sparse Matrices for Information Retrieval
2012-20	Ali Bahramisharif (RUN) Covert Visual Spatial Attention, a Robust Paradigm for Brain-Computer Interfacing
2012-19	Helen Schonenberg (TUE)

	What's Next? Operational Support for Business Process Execution
2012-18	Eltjo Poort (VU) Improving Solution Architecting Practices
2012-17	Amal Elgammal (UvT) Towards a Comprehensive Framework for Business Process Compliance
2012-16	Fiemke Both (VU) Helping people by understanding them - Ambient Agents supporting task execution and depression treatment
2012-15	Natalie van der Wal (VU) Social Agents. Agent-Based Modelling of Integrated Internal and Social Dynamics of Cognitive and Affective Processes.
2012-14	Evgeny Knutov(TUE) Generic Adaptation Framework for Unifying Adaptive Web-based Systems
2012-13	Suleman Shahid (UvT) Fun and Face: Exploring non-verbal expressions of emotion during playful interactions
2012-12	Kees van der Sluijs (TUE) Model Driven Design and Data Integration in Semantic Web Information Systems
2012-11	J.C.B. Rantham Prabhakara (TUE) Process Mining in the Large: Preprocessing, Discovery, and Diagnostics
2012-10	David Smits (TUE) Towards a Generic Distributed Adaptive Hypermedia Environment
2012-09	Ricardo Neisse (UT) Trust and Privacy Management Support for Context-Aware Service Platforms
2012-08	Gerben de Vries (UVA) Kernel Methods for Vessel Trajectories
2012-07	Rianne van Lambalgen (VU) When the Going Gets Tough: Exploring Agent-based Models of Human Performance under Demanding Conditions
2012-06	Wolfgang Reinhardt (OU) Awareness Support for Knowledge Workers in Research Networks
2012-05	Marijn Plomp (UU) Maturing Interorganisational Information Systems
2012-04	Jurriaan Souer (UU)

Development of Content Management System-based Web Applications
2012-03 Adam Vanya (VU)
Supporting Architecture Evolution by Mining Software Repositories
2012-02 Muhammad Umair (VU)
Adaptivity, emotion, and Rationality in Human and Ambient Agent Models
2012-01 Terry Kakeeto (UvT)
Relationship Marketing for SMEs in Uganda

2011

2011-47 Azizi Bin Ab Aziz (VU)
Exploring Computational Models for Intelligent Support of Persons with Depression
2011-46 Beibei Hu (TUD)
Towards Contextualized Information Delivery: A Rule-based Architecture for the Domain of Mobile Police Work
2011-45 Herman Stehouwer (UvT)
Statistical Language Models for Alternative Sequence Selection
2011-44 Boris Reuderink (UT)
Robust Brain-Computer Interfaces
2011-43 Henk van der Schuur (UU)
Process Improvement through Software Operation Knowledge
2011-42 Michal Sindlar (UU)
Explaining Behavior through Mental State Attribution
2011-41 Luan Ibraimi (UT)
Cryptographically Enforced Distributed Data Access Control
2011-40 Viktor Clerc (VU)
Architectural Knowledge Management in Global Software Development
2011-39 Joost Westra (UU)
Organizing Adaptation using Agents in Serious Games
2011-38 Nyree Lemmens (UM)
Bee-inspired Distributed Optimization
2011-37 Adriana Burlutiu (RUN)
Machine Learning for Pairwise Data, Applications for Preference Learning and Supervised Network Inference
2011-36 Erik van der Spek (UU)

	Experiments in serious game design: a cognitive approach
2011-35	Maaike Harbers (UU) Explaining Agent Behavior in Virtual Training
2011-34	Paolo Turrini (UU) Strategic Reasoning in Interdependence: Logical and Game-theoretical Investigations
2011-33	Tom van der Weide (UU) Arguing to Motivate Decisions
2011-32	Nees-Jan van Eck (EUR) Methodological Advances in Bibliometric Mapping of Science
2011-31	Ludo Waltman (EUR) Computational and Game-Theoretic Approaches for Modeling Bounded Rationality
2011-30	Egon van den Broek (UT) Affective Signal Processing (ASP): Unraveling the mystery of emotions
2011-29	Faisal Kamiran (TUE) Discrimination-aware Classification
2011-28	Rianne Kaptein(UVA) Effective Focused Retrieval by Exploiting Query Context and Document Structure
2011-27	Aniel Bhulai (VU) Dynamic website optimization through autonomous management of design patterns
2011-26	Matthijs Aart Pontier (VU) Virtual Agents for Human Communication - Emotion Regulation and Involvement-Distance Trade-Offs in Embodied Conversational Agents and Robots
2011-25	Syed Waqar ul Qounain Jaffry (VU) Analysis and Validation of Models for Trust Dynamics
2011-24	Herwin van Welbergen (UT) Behavior Generation for Interpersonal Coordination with Virtual Humans On Specifying, Scheduling and Realizing Multimodal Virtual Human Behavior
2011-23	Wouter Weerkamp (UVA) Finding People and their Utterances in Social Media
2011-22	Junte Zhang (UVA) System Evaluation of Archival Description and Access
2011-21	Linda Terlouw (TUD) Modularization and Specification of Service-Oriented Systems
2011-20	Qing Gu (VU) Guiding service-oriented software engineering - A view-based approach

2011-19	Ellen Rusman (OU) The Mind's Eye on Personal Profiles
2011-18	Mark Ponsen (UM) Strategic Decision-Making in complex games
2011-17	Jiyin He (UVA) Exploring Topic Structure: Coherence, Diversity and Relatedness
2011-16	Maarten Schadd (UM) Selective Search in Games of Different Complexity
2011-15	Marijn Koolen (UvA) The Meaning of Structure: the Value of Link Evidence for Information Retrieval
2011-14	Milan Lovric (EUR) Behavioral Finance and Agent-Based Artificial Markets
2011-13	Xiaoyu Mao (UvT) Airport under Control. Multiagent Scheduling for Airport Ground Handling
2011-12	Carmen Bratosin (TUE) Grid Architecture for Distributed Process Mining
2011-11	Dhaval Vyas (UT) Designing for Awareness: An Experience-focused HCI Perspective
2011-10	Bart Bogaert (UvT) Cloud Content Contention
2011-09	Tim de Jong (OU) Contextualised Mobile Media for Learning
2011-08	Nieske Vergunst (UU) BDI-based Generation of Robust Task-Oriented Dialogues
2011-07	Yujia Cao (UT) Multimodal Information Presentation for High Load Human Computer Interaction
2011-06	Yiwen Wang (TUE) Semantically-Enhanced Recommendations in Cultural Heritage
2011-05	Base van der Raadt (VU) Enterprise Architecture Coming of Age - Increasing the Performance of an Emerging Discipline
2011-04	Hado van Hasselt (UU) Insights in Reinforcement Learning; Formal analysis and empirical evaluation of temporal-difference learning algorithms
2011-03	Jan Martijn van der Werf (TUE) Compositional Design and Verification of Component-Based Information Systems

2011-02 Nick Tinnemeier(UU)
Organizing Agent Organizations. Syntax and Operational Semantics of an Organization-Oriented Programming Language

2011-01 Botond Cseke (RUN)
Variational Algorithms for Bayesian Inference in Latent Gaussian Models

2010

2010-53 Edgar Meij (UVA)
Combining Concepts and Language Models for Information Access

2010-52 Peter-Paul van Maanen (VU)
Adaptive Support for Human-Computer Teams: Exploring the Use of Cognitive Models of Trust and Attention

2010-51 Alia Khairia Amin (CWI)
Understanding and supporting information seeking tasks in multiple sources

2010-50 Bouke Huurnink (UVA)
Search in Audiovisual Broadcast Archives

2010-49 Jahn-Takeshi Saito (UM)
Solving difficult game positions

2010-48 Withdrawn

2010-47 Chen Li (UT)
Mining Process Model Variants: Challenges, Techniques, Examples

2010-46 Vincent Pijpers (VU)
e3alignment: Exploring Inter-Organizational Business-ICT Alignment

2010-45 Vasilios Andrikopoulos (UvT)
A theory and model for the evolution of software services

2010-44 Pieter Bellekens (TUE)
An Approach towards Context-sensitive and User-adapted Access to Heterogeneous Data Sources, Illustrated in the Television Domain

2010-43 Peter van Kranenburg (UU)
A Computational Approach to Content-Based Retrieval of Folk Song Melodies

2010-42 Sybren de Kinderen (VU)
Needs-driven service bundling in a multi-supplier setting - the computational e3-service approach

2010-41	Guillaume Chaslot (UM) Monte-Carlo Tree Search
2010-40	Mark van Assem (VU) Converting and Integrating Vocabularies for the Semantic Web
2010-39	Ghazanfar Farooq Siddiqui (VU) Integrative modeling of emotions in virtual agents
2010-38	Dirk Fahland (TUE) From Scenarios to components
2010-37	Niels Lohmann (TUE) Correctness of services and their composition
2010-36	Jose Janssen (OU) Paving the Way for Lifelong Learning; Facilitating competence development through a learning path specification
2010-35	Dolf Trieschnigg (UT) Proof of Concept: Concept-based Biomedical Information Retrieval
2010-34	Teduh Dirgahayu (UT) Interaction Design in Service Compositions
2010-33	Robin Aly (UT) Modeling Representation Uncertainty in Concept-Based Multimedia Retrieval
2010-32	Marcel Hiel (UvT) An Adaptive Service Oriented Architecture: Automatically solving Interoperability Problems
2010-31	Victor de Boer (UVA) Ontology Enrichment from Heterogeneous Sources on the Web
2010-30	Marieke van Erp (UvT) Accessing Natural History - Discoveries in data cleaning, structuring, and retrieval
2010-29	Stratos Idreos(CWI) Database Cracking: Towards Auto-tuning Database Kernels
2010-28	Arne Koopman (UU) Characteristic Relational Patterns
2010-27	Marten Voulon (UL) Automatisch contracteren
2010-26	Ying Zhang (CWI) XRPC: Efficient Distributed Query Processing on Heterogeneous XQuery Engines
2010-25	Zulfiqar Ali Memon (VU) Modelling Human-Awareness for Ambient Agents: A Human Mindreading Perspective
2010-24	Dmytro Tykhonov

	Designing Generic and Efficient Negotiation Strategies
2010-23	Bas Steunebrink (UU) The Logical Structure of Emotions
2010-22	Michiel Hildebrand (CWI) End-user Support for Access to Heterogeneous Linked Data
2010-21	Harold van Heerde (UT) Privacy-aware data management by means of data degradation
2010-20	Ivo Swartjes (UT) Whose Story Is It Anyway? How Improve Informs Agency and Authorship of Emergent Narrative
2010-19	Henriette Cramer (UvA) People's Responses to Autonomous and Adaptive Systems
2010-18	Charlotte Gerritsen (VU) Caught in the Act: Investigating Crime by Agent-Based Simulation
2010-17	Spyros Kotoulas (VU) Scalable Discovery of Networked Resources: Algorithms, Infrastructure, Applications
2010-16	Sicco Verwer (TUD) Efficient Identification of Timed Automata, theory and practice
2010-15	Lianne Bodenstaff (UT) Managing Dependency Relations in Inter-Organizational Models
2010-14	Sander van Splunter (VU) Automated Web Service Reconfiguration
2010-13	Gianluigi Folino (RUN) High Performance Data Mining using Bio-inspired techniques
2010-12	Susan van den Braak (UU) Sensemaking software for crime analysis
2010-11	Adriaan Ter Mors (TUD) The world according to MARP: Multi-Agent Route Planning
2010-10	Rebecca Ong (UL) Mobile Communication and Protection of Children
2010-09	Hugo Kielman (UL) A Politiele gegevensverwerking en Privacy, Naar een effectieve waarborging
2010-08	Krzysztof Siewicz (UL) Towards an Improved Regulatory Framework of Free Software. Protecting user freedoms in a world of software communities and eGovernments

2010-07 Wim Fikkert (UT)
Gesture interaction at a Distance
2010-06 Sander Bakkes (UvT)
Rapid Adaptation of Video Game AI
2010-05 Claudia Hauff (UT)
Predicting the Effectiveness of Queries and Retrieval Systems
2010-04 Olga Kulyk (UT)
Do You Know What I Know? Situational Awareness of Co-located Teams in Multidisplay Environments
2010-03 Joost Geurts (CWI)
A Document Engineering Model and Processing Framework for Multimedia documents
2010-02 Ingo Wassink (UT)
Work flows in Life Science
2010-01 Matthijs van Leeuwen (UU)
Patterns that Matter

2009

2009-46 Loredana Afanasiev (UvA)
Querying XML: Benchmarks and Recursion
2009-45 Jilles Vreeken (UU)
Making Pattern Mining Useful
2009-44 Roberto Santana Tapia (UT)
Assessing Business-IT Alignment in Networked Organizations
2009-43 Virginia Nunes Leal Franqueira (UT)
Finding Multi-step Attacks in Computer Networks using Heuristic Search and Mobile Ambients
2009-42 Toine Bogers (UvT)
Recommender Systems for Social Bookmarking
2009-41 Igor Berezhnyy (UvT)
Digital Analysis of Paintings
2009-40 Stephan Raaijmakers (UvT)
Multinomial Language Learning: Investigations into the Geometry of Language
2009-39 Christian Stahl (TUE, Humboldt-Universität zu Berlin)
Service Substitution – A Behavioral Approach Based on Petri Nets
2009-38 Riina Vuorikari (OU)
Tags and self-organisation: a metadata ecology for learning resources in a multilingual context

2009-37 Hendrik Drachsler (OU)
Navigation Support for Learners in Informal Learning Networks

2009-36 Marco Kalz (OU)
Placement support for learners in learning networks

2009-35 Wouter Koelewijn (UL)
Privacy en Politiegegevens; Over geautomatiseerde normatieve informatie-uitwisseling

2009-34 Inge van de Weerd (UU)
Advancing in Software Product Management: An Incremental Method Engineering Approach

2009-33 Khiet Truong (UT)
How Does Real Affect Affect Affect Recognition In Speech?

2009-32 Rik Farenhorst (VU) and Remco de Boer (VU)
Architectural Knowledge Management: Supporting Architects and Auditors

2009-31 Sofiya Katrenko (UVA)
A Closer Look at Learning Relations from Text

2009-30 Marcin Zukowski (CWI)
Balancing vectorized query execution with bandwidth-optimized storage

2009-29 Stanislav Pokraev (UT)
Model-Driven Semantic Integration of Service-Oriented Applications

2009-28 Sander Evers (UT)
Sensor Data Management with Probabilistic Models

2009-27 Christian Glahn (OU)
Contextual Support of social Engagement and Reflection on the Web

2009-26 Fernando Koch (UU)
An Agent-Based Model for the Development of Intelligent Mobile Services

2009-25 Alex van Ballegooij (CWI)
RAM: Array Database Management through Relational Mapping

2009-24 Annerieke Heuvelink (VUA)
Cognitive Models for Training Simulations

2009-23 Peter Hofgesang (VU)
Modelling Web Usage in a Changing Environment

2009-22 Pavel Serdyukov (UT)
Search For Expertise: Going beyond direct evidence

2009-21 Stijn Vanderlooy (UM)
Ranking and Reliable Classification

2009-20 Bob van der Vecht (UU)

	Adjustable Autonomy: Controling Influences on Decision Making
2009-19	Valentin Robu (CWI) Modeling Preferences, Strategic Reasoning and Collaboration in Agent-Mediated Electronic Markets
2009-18	Fabian Groffen (CWI) Armada, An Evolving Database System
2009-17	Laurens van der Maaten (UvT) Feature Extraction from Visual Data
2009-16	Fritz Reul (UvT) New Architectures in Computer Chess
2009-15	Rinke Hoekstra (UVA) Ontology Representation - Design Patterns and Ontologies that Make Sense
2009-14	Maksym Korotkiy (VU) From ontology-enabled services to service-enabled ontologies (making ontologies work in e-science with ONTO-SOA)
2009-13	Steven de Jong (UM) Fairness in Multi-Agent Systems
2009-12	Peter Massuthe (TUE, Humboldt-Universität zu Berlin) Operating Guidelines for Services
2009-11	Alexander Boer (UVA) Legal Theory, Sources of Law & the Semantic Web
2009-10	Jan Wielemaker (UVA) Logic programming for knowledge-intensive interactive applications
2009-09	Benjamin Kanagwa (RUN) Design, Discovery and Construction of Service-oriented Systems
2009-08	Volker Nannen (VU) Evolutionary Agent-Based Policy Analysis in Dynamic Environments
2009-07	Ronald Poppe (UT) Discriminative Vision-Based Recovery and Recognition of Human Motion
2009-06	Muhammad Subianto (UU) Understanding Classification
2009-05	Sietse Overbeek (RUN) Bridging Supply and Demand for Knowledge Intensive Tasks - Based on Knowledge, Cognition, and Quality
2009-04	Josephine Nabukenya (RUN) Improving the Quality of Organisational Policy Making using Collaboration Engineering
2009-03	Hans Stol (UvT)

	A Framework for Evidence-based Policy Making Using IT
2009-02	Willem Robert van Hage (VU) Evaluating Ontology-Alignment Techniques
2009-01	Rasa Jurgelenaite (RUN) Symmetric Causal Independence Models