EGameFlow in a Serious Game: Gaming Experience with the Same Game Design but Different Learning Content

Research-in-Progress

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Abstract

The development effort of game-based learning applications is very time-consuming and costly, especially when applications are developed that provide students an enjoyable gaming experience and support them to achieve their learning objectives. This is largely to be explained by the iterative development process with the conduction of playtests. Therefore, this study analyzes whether an identical gaming and learning experience is achieved with the same game design but different learning contents. A serious game for learning information literacy that was developed and iteratively improved through three conducted playtests is used in this study. The results show that an identical gaming and learning experience is achieved. This makes it possible to re-use the game design in combination with other learning contents without negatively affecting the learner's playing and learning experience.

Keywords: *Game-based Learning, Serious Game, EGameFlow, Game Design, Gaming Experience*

Introduction

Game-based Learning (GBL) is defined as integration of game elements in instructional sessions and is currently a widespread trend (Hamari et al. 2014). A distinction is made between gamification, which describes the integration of only a few game elements in a non-gaming context (e.g. education), and serious games, which are defined by the development of a full-fledged game with fixed rules and objectives (Deterding et al. 2011). Both design forms have common aims. Game elements are used to motivate learners (Kapp 2012). Learners should have more fun with learning content and be more engaged in the learning process (Kapp 2012). GBL promotes different learning processes. On the one hand, active learning is supported by a continuous game cycle. On the other hand, constructive learning is supported by trying out different action alternatives (trial and error method) and by an individual interpretation of the experiences made. In addition, social learning is promoted through cooperation and competition with other players, but also emotional learning through personal identification with game events. Situated learning is also possible by assuming different roles in the game (Meier and Seufert 2002). The use of game elements in education can therefore lead to a positive influence on learning success (Eckardt and Robra-Bissantz 2018). However, achieving the positive effects associated with GBL is related with some challenges.

The analysis of some commercially successful GBL applications has shown that the connection between gaming and learning content is often not achieved. For example, in some cases, play and

learning areas are separated from each other or learning content is completely detached from the story of the game (Jantke 2007). Even the fun achieved by commercially successful games is often not reached by GBL applications. Standards of technical functionality, aesthetics or game design often cannot be fulfilled because of smaller financial resources or other focuses in the development process (Shen et al. 2009). For example, the special design requirements for GBL applications to motivate learners are difficult to fulfil because learning content and game elements must be closely linked. Additionally, a didactic framework must be added to achieve the desired learning objectives (Kerres et al. 2009).

The development process of a well thought-out GBL application therefore takes a long time and requires creativity, technical skills and comprehensive testing (Whitton 2012). The process of developing a traditional game is an iteration of conceptualization, prototyping and playtesting (Fullerton 2014). The development process of educational games is a little different. After defining learning objectives, the application is designed, whereby the game design has to be closely linked to learning objectives. After conceptualization, a prototype is created to perform a first playtest session. Fulfills the developed GBL application all aims regarding fun and the achievement of learning objectives, a transfer of the application into the teaching practice takes place. Otherwise a revision is necessary (Boller und Kapp 2017).

Synergy effects should be used to take advantage of the positive effects connected to GBL and to support further dissemination of GBL applications. Existing game designs, specially developed for certain learning contents, can be adopted and reused according to own requirements. Although, learning content is exchanged, the game concept can still be used. This procedure reduces the effort required for the development process and existing concepts can be reused (Westera et al. 2008). The main learning topic the game concept is designed for remains, but other thematic focuses can be set in the knowledge transfer and task solving.

The aim of this work is to analyze whether the game and learning experience is identical to the same game design and different learning contents. This is necessary to establish a successful application for instruction. For this purpose, the gaming experience of a serious game for learning information literacy is analyzed in three different versions as a first step.

Related Work

Playing commercial games developed exclusively for entertainment purposes is a leisure activity that requires a high degree of concentration and attention. Players ideally forget the real environment and immerse themselves completely in the created game world (Bopp 2005). This phenomenon is also known as the flow experience. Csíkszentmihályi (1990) defines Flow as the optimal mental state a person is neither over- nor underchallenged. This flow state enables the players to build up knowledge and skills step by step as a result of the continuous cyclic course of action consisting of feedback and reaction to an action (Bopp 2005). The designers of GBL applications also want to achieve this state. For this reason, they try to achieve a high gaming experience in addition to the learning objectives (Eckardt and Robra-Bissantz 2018).

Nevertheless, there are only a few studies that analyze gaming experience in GBL applications, e.g. Fu et al. (2009), because the focus so far has mainly been on the development and not on the evaluation of the effectiveness of applications or on verifying the achievement of the learning objectives (Sitzmann 2011). For example, Fu et al. (2009) and Wu and Wang (2011) have reviewed various learning games in terms of their gaming experience. While the learning game tested by Wu and Wang (2011) provides knowledge about a city, students learn different technical skills in the GBL applications by Fu et al. (2009). However, the results of both studies show that the use or absence of certain game elements varies the gaming experience. Both studies analyzed different game designs in connection to different learning contents. Furthermore, Khenissi et al. (2014) conducted a study on the effectiveness of serious games for students. Their results showed an improvement in the level of knowledge and convergence in student satisfaction. For this purpose, two games for learning programming were compared with different game designs. While the first group learned with a learning game based on the commercial game Pac-Man, the second group learned with a learning

game, especially developed for educational purposes. The knowledge improvement of the second group was higher. This underlines the importance of conceptualization and re-use of games specifically designed for learning. In a study conducted by Sillaots (2014), research seminars of various courses (IT management and information and communication technology) were gamified. Identical game elements were used, and different scientific papers were critically discussed. The students experienced a flow state but perceived the dimension of autonomy (freedom of action) differently. This implementation corresponds more to a gamification solution. Some game elements were used in similarly structured courses.

In previous research works, the gaming experience has already been tested for different game designs in connection with different learning contents (Fu et al. 2009; Wu and Wang 2011). In addition, a comparative analysis of adapted commercial games and games that are only developed with learning purposes was conducted (Khenissi et al. 2014). The integration of identical game elements in different courses was analyzed as well (Sillaots 2014). Even though the work of Sillaots (2014) is similar, there was no analysis of courses that took place exclusively digitally. Consequently, an analysis of the gaming experience of GBL applications in the form of serious games with an identical game design and the same main learning topic but with different focuses has not yet been carried out to the best of our knowledge. This will be conducted in this work. The results are intended to provide initial insights into whether a serious game designed specifically for instruction achieves an identical gaming and learning experience like the same serious game with adapted learning content. Thereby, a reuse with minimal effort for adaption and development work would be supported.

EGameFlow Model

Csíkszentmihályi (1990) identifies several factors, such as concentration, challenge, control, clear goal, immersion and feedback that influence the state of Flow. Many researchers applied these factors and the idea of Flow into game development. For example, as Flow Zone (Pilke 2004) or by explaining the computer game flow in children (Inal and Cagiltay 2007). Sweetser and Wyeth (2005) used the existing literature to develop GameFlow. This model supports measuring the enjoyment of a game. Learning games are different to traditional commercial games because of different goals. Traditional games are just for fun and learning games try to convey knowledge through an enjoyable gaming experience (Fu et al. 2009). For this reason, measuring the achieved learning objectives is important to add in the evaluation of gaming experience (Freitas and Oliver 2006; Fu et al. 2009). In the developed EGameFlow model, this aspect is added so that the model measures the gaming experience of digital learning games with eight dimensions: concentration, clear goal, feedback, challenge, autonomy, immersion, social interaction and knowledge improvement (Fu et al. 2009). Concentration, the first dimension of the EGameFlow model, means to provide activities to focus players attention in the learning game. Thereby, stress situations have to be minimized because they negatively influence players concentration. Throughout the complete gaming experience, game tasks have to be explained so that players can focus on reaching the next objective (clear goal dimension). Feedback allows the players to know his/her current stage of knowledge and progress at every point in the learning game. As a result, the players know what they must do to reach the next game goal. Challenges should be provided that fit to the players level of skill. With increasing skills, the level of difficulty should be increased. The dimension immersion means to offer the players a feeling of engagement and involvement through the game activities. Allowing players to interact socially should be supported through e.g. team tasks or chat functions to support the dimension social interaction. Furthermore, supporting the dimension of knowledge improvement means to increase the level of skills and knowledge of the players so that learning objectives can be achieved (Fu et al. 2009).

The EGameFlow model is used for the study in this work to get a comprehensive overview about the gaming and learning experience that is achieved with the three tested game versions.

Game Design Process of the Serious Game "Lost in Antarctica"

The development of the open source serious game in this paper was done after the game design process for entertaining games by Fullerton (2014) and was complemented by some aspects, caused by the learning context (Boller and Kapp 2017; Eckardt and Robra-Bissantz 2018).

The first step was to define the learning content and objectives. Library staff, as experts in the field of information literacy, have done this. The planning of the learning content is first necessary to create a structured game concept based on it.

Ideas are necessary for conceptualization. A project with the target group of the serious game, the students, was carried out to generate ideas and create a concept. 45 students, divided into 12 groups, developed game ideas and defined game elements (e.g. points and avatars). They regularly presented their elaborated ideas and revised them based on the feedback received. After several revisions, the students cooperatively chose a winning idea and the game name "Lost in Antarctica". Figure 1 shows 2 screenshots of the serious game.

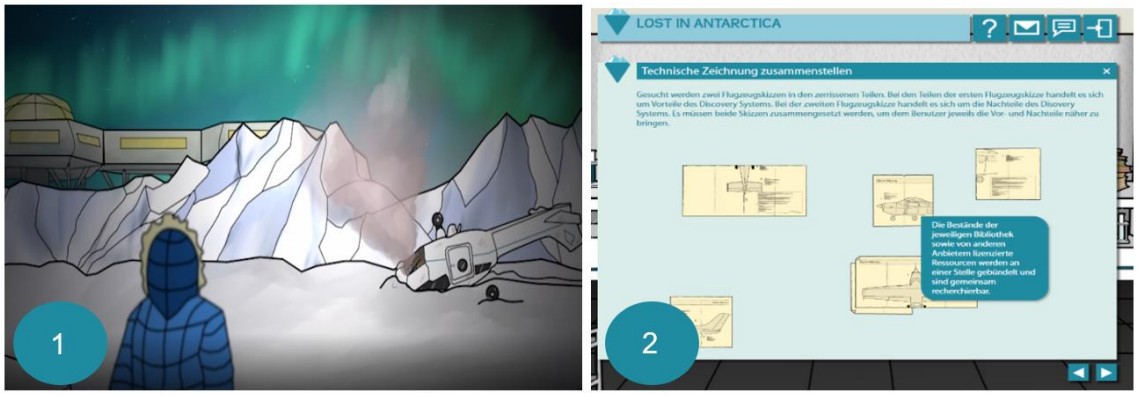

Figure 1. Screenshots of the Serious Game

Within the game story, students travel after avatar creation as a group of scientists to a research expedition to the South Pole. As a result of a snow storm, their aircraft crashes (screen 1). For this reason, in addition to their research work, the aircraft must also be repaired. In different levels, which are integrated into the game story, a knowledge transfer and an application of the learned contents takes place when solving exercises (screen 2). Gaining a certain number of points indicates the successful completion of a level. For each completed level, students get a component to repair the defective aircraft. Additional collected points can be exchanged on a market place for mini games (e.g. Penguin-Man) that are just for fun. An individual and team ranking allows a comparison between students (Eckardt and Robra-Bissantz 2016).

After the game concept had been finalized, a first prototype was implemented. The serious game "Lost in Antarctica" should be available as a browser game, so that the programming took place with PHP, HTML, CSS and JavaScript. For the prototype, the introduction into the serious game with avatar creation was implemented and the first four of a total of 12 levels. In each level, a different focus of information literacy (e.g. internet search, scientific writing or copyright) is learned.

This digital prototype was evaluated by 46 students within a first playtest session regarding overall impression, game design, usability and graphic. Overall, the evaluation was very positive. However, by naming positive and negative aspects of the game in an open question, it was also possible to identify some improvement potentials. For example, students often missed explanations about what to do next. For this reason, a feedback button was added, so that the students get in direct contact with the teachers, as well as a help video explaining the game functions. Furthermore, students criticized the minimum score per level, which was too easy to achieve. Therefore, the minimum score was increased (Eckardt et al. 2018).

After the revision of the digital prototype based on the feedback from the first playtest session, a second playtest session with 82 students followed during the first run with all twelve levels of the

serious game. The EGameFlow model was used to measure the gaming experience within the game-based learning application (Fu et al. 2009). The dimensions feedback, clear goal formulation of objectives and knowledge gain were assessed positively, whereas the dimensions concentration, challenge and autonomy were only assessed with a slightly positive tendency. Social interaction and immersion were rated negatively, which is why improvements in serious game were necessary. For example, more graphics are used to illustrate the game story and to increase immersion. Cooperative elements of the game are increasingly emphasized. For example, notifications of new messages appear in team chat. Further measures designed to improve the remaining dimensions already perceived as positive were also taken. Hints for solutions were added to improve concentration and clear goal formulation. This should help students to understand the tasks better. Additional created options within the game world should increase autonomy (Eckardt et al. 2018).

In another playtest session with 142 students, these changes led to significant improvements in almost all dimensions of the EGameFlow model. No significant improvement was observed for the knowledge improvement dimension. However, this measurement was carried out through subjective self-assessment, which must be critically noted in the measurement of knowledge. For more detailed information, it is therefore useful to include an objective measurement, for example by answering knowledge questions (Eckardt and Robra-Bissantz 2018).

All in all, this iterative development process with playtests and revisions has shown that improvements of the experienced gaming experience are possible. It also becomes clear that working with students helps to design a game-based learning application that students want to work with or learn with. Nevertheless, this iterative development process was only done for a first version of the serious game.

This game concept was transferred for a total of three versions of the serious game for learning information literacy at three universities. In all versions, other aspects of information literacy are deepened. This can be explained with different requirements for information literacy instruction. For example, for some students, scientific writing is important and for others literature search is important because other systems are used in the department than usual. Figure 2 shows the game structure combined with learning topics of the three versions. The iterative development process, described above, was done for game version 1.

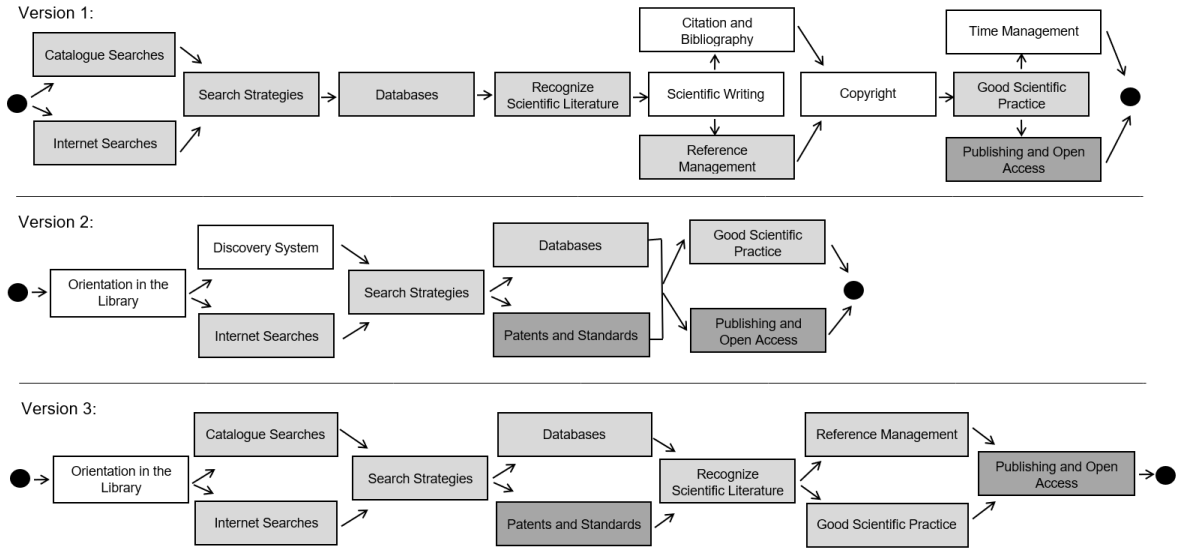

Figure 2. Versions and Learning Contents of the Serious Game

In version 1, learning information literacy takes place within 12 levels. In version 2 other aspects of information literacy are partly taught in eight levels. Ten levels are used for information literacy instruction in version 3. The location-dependent requirements on the learning content as well as the different levels need a change in the static game structure and story. The levels reused of version 1 in version 2 and 3 are shown in light grey. The levels developed for version 2, which will be used in the other two versions, are shown in dark grey.

The different requirements for such a GBL application pose a challenge for subsequent use outside the project partners involved in the development process. It is also uncertain whether the same results will be achieved with the adapted applications.

Study Design and Results

In this study, the achieved gaming experience by all three versions of the serious game is tested to find out whether the gaming experience is different due to the modifications of the learning content. Students, as the target group of the application, test the serious game. At the time of the study, all participants have no experience with the game, which helps to analyze their first impression. Participants are randomly assigned to one of the three game versions and have one hour to test the game-based learning application. During this time, it is not possible to finish the game completely. Instead the participants have the chance to get a general impression of the game.

After the one-hour test phase, participants will be required to complete an online questionnaire to collect their gaming experience. The game and learning experience is measured with the EGameFlow model (Fu et al. 2009). Thereby, a seven point Likert scale is used (1 = extremely disagree, …, 7 = extremely agree).

65 students were invited to participate in the study. The students consisted of 46 males and 19 females, with the mean age being 25. All participants are students from technical or economic degree courses. Consequently, all students share approximately the same level of knowledge and are close to completing their Master's degree (within a few months). For this reason, they are intrinsically motivated to learn information literacy competencies and the study participants correspond to the target group of the application. Due to the same level of prior knowledge, no knowledge-induced bias between the groups is to be expected for quantitative analysis. 25 students tested game version 1, 22 students played version 2 and 18 students tested game version 3.

The mean values over all items of the respective dimensions of the EGameFlow model are visualized in a network diagram in Figure 3. In general, all three game versions achieved similar results in the measured dimensions. Nevertheless, the dimensions concentration, goal clarity, feedback, challenge, autonomy and knowledge improvement are positively evaluated in all three game versions and the remaining dimensions immersion and social interaction achieved only results with a slight positive trend for the game version 2 and 3. Participants, who tested game version 1 evaluated social interaction with a mean value of 3.5 (moderately successful) and immersion with a slight negative trend. These differences can be explained by the different progress of the testers. Some players may not have activated certain functionalities (e.g. team chat) yet.

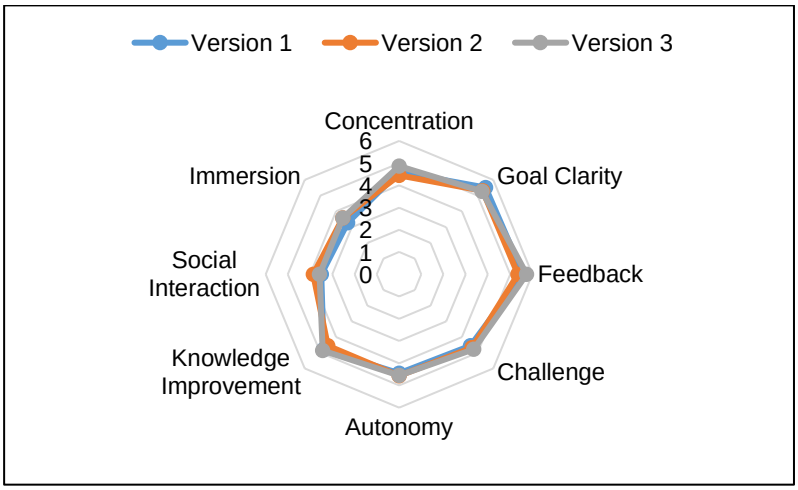

Figure 3. EGameFlow of the Three Game Versions

A MANOVA was performed to determine if the three samples significantly differ regarding dimensions. The Wilks-Lambda test resulted in no significant multivariate influence across all

variables (*Wilks* $\lambda = 0{,}75$, $F(16, 110) = 1{,}09$, $p = 0{,}378$). Mean values (MV) and standard deviations (STD) of all dimensions of the EGameFlow model are summarized in Table 1.

Table 1. Results Mean Value and Standard Deviation

Factor	Version 1		Version 2		Version 3	
	MV	STD	MV	STD	MV	STD
Concentration	4.61	0.95	4.45	0.86	4.86	0.79
Goal Clarity	5.51	0.99	5.32	0.93	5.28	0.86
Feedback	5.59	0.91	5.35	0.84	5.74	0.95
Challenge	4.55	0.90	4.66	0.94	4.76	0.92
Autonomy	4.45	1.01	4.57	1.07	4.56	0.88
Knowledge Improvement	4.79	0.88	4.54	1.20	4.85	1.12
Social Interaction	3.50	1.06	3.86	0.80	3.58	1.26
Immersion	3.28	1.02	3.58	0.89	3.58	1.19

Consequently, the results show no significant differences between the tested game versions for all measured dimensions of the EGameFlow model. This means, that the gaming and learning experience is identical in all three game versions.

Conclusion and Future Research

The results have shown that the gaming and learning experience of the three game versions is identical. The dimensions concentration, goal clarity, feedback, challenge, autonomy, knowledge improvement, social interaction and immersion received similar good values by the participants. These results enable the reuse of elaborately developed game-based learning applications. The adaptation of some learning contents is possible while maintaining the achieved gaming and learning experience. In practice, this means time- and cost-saving development of game-based learning applications and thus the promotion of their dissemination.

However, the results obtained in this study are limited and further research is needed. Until now, the analysis of the gaming and learning experience has only taken place in a serious game for learning information literacy. Other learning contents have not been analyzed so far. Therefore, this study should be repeated for further game-based learning applications with other thematic focuses. In the EGameFlow model, the achievement of the learning objectives was only assessed through the subjective evaluation of one's own increase in knowledge. However, an objective measurement is also useful for testing knowledge and verifying the achievement of learning objectives (Brucks 1985). For this reason, a future study should evaluate knowledge subjectively and objectively to obtain more accurate results in terms of learning success and learning experience.

In summary, it can be noted that it is not always necessary to develop new game-based learning applications. The reuse of such applications with modified learning content is possible while maintaining a high level of gaming and learning experience.

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