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Facing the Challenge: Evaluation of Serious Games

Herausforderung Serious Games: Evaluation von Spielen mit Lerncharakter

Serious games_Assessment_Games Market_Serious Games Taxonomy_Classification_Framework_Health Games_Educational Games

Zusammenfassung. Diese Arbeit gibt einen Überblick über den aktuellen Forschungsstand im Bereich der Serious Games. Wir behandeln Fragen und Probleme bezüglich des Konzepts von Serious Games – Spiele, die den Anspruch haben, mehr zu sein, als bloße Unterhaltung und Wissen auf spielerische Art und Weise vermitteln möchten. Wir präsentieren Anwendungsgebiete wie Militär, Gesundheit oder Bildung sowie neueste Trends. Zudem werden positive Auswirkungen auf die persönliche Entwicklung des Spielers aufgezeigt. Aufgrund mangelnder empirischer Belege zur Wirksamkeit derartiger Spieler präsentieren wir eine Auswahl vielversprechender Ansätze zur Gestaltung und Evaluation. Zusammenfassend werden mehr wissenschaftliche Untersuchungen zur Effektivität von Serious Games benötigt, deren Durchführung bereits zu Beginn des Design- und Entwicklungsprozesses berücksichtigt werden sollte.

Summary. This paper gives an overview about the current academic research state of the art in the field of serious games. We illustrate issues concerning the concept of serious games which are games that claim to be more than just entertainment and pursue the serious aim to transfer knowledge in a playful way. We present application areas such as military, health or education and identify new trends within the field. An overview of the positive impacts on the players' development by playing such games is given as well. As there is still not enough empirical evidence on the effectiveness of serious games we present some promising approaches for the design and assessment of serious games. We conclude that more experimental studies have to be conducted which already have to be considered at the very beginning of the design process.

1. Introduction

In the last years the intention to use serious games in order to reach a behavior modification in real life became very popular. One assumes that serious games can change behavior in a measureable way. Solving intense problems by playing a digital game can be considered as a new form of human cooperation (Wolters 2013). In terms of the actual trend of "mobile learning" which offers the opportunity to play digital games anytime and anywhere (Park 2011), it becomes possible to transfer knowledge in a playful way in people's free time, independent of school teaching for example. By involving community functions, different players can build a network and solve the serious games' tasks together. Empirical studies (e.g. Wolters 2013) referring to

the market share of serious games imply that the estimated market share in the space of the whole game industry is about 2–5 % with a large room for improvement, which equates a market volume about 1,5–2,5 billion euro per year. However this quotation is a little bit inaccurate. There are many concepts which are used analogous to the term serious game such as e-learning, edutainment, game-based learning, and digital game-based learning (Susi, Johannesson and Backlund 2007). But for sure there is evidence that serious games have positive effects on cognitive or affective skills (Wouters, van der Spek and van Oostendorp 2009) and can accomplish attitudinal change (Susi et al. 2007). Because of these supposed potentials the development of serious games became an object of academic research in 2002 (Kato 2010). In the same year David Rejeski and Ben Sawyer established the "Serious

Game Initiative" in the Woodrow Wilson International Center in Washington D.C. (Ke and Grabowski 2007), which "is focused on uses for games in exploring management and leadership challenges facing the public sector" (Serious Games Initiative 2013).

In consequence the media and games market create the impression that "all games are good for all learning outcomes, which is categorically not the case" (Susi et al. 2007, p. 9). The challenge now is to identify when and why which games are effective regarding a learning purpose. The following paper tries to establish some clarification. Therefore first an explanation of the concept serious game itself is given and it is bordered from entertainment games. In the second part different application areas of serious games are illustrated. The third section gives an overview of the different kinds of learning outcomes

	Serious Games	Entertainment Games
Task vs. rich experience	Problem solving in focus	Rich experiences preferred
Focus	Important elements of learning	To have fun
Simulations	Assumptions necessary for workable simulations	Simplified simulation processes
Communication	Should reflect natural (i.e.: non-perfect) communication	Communication is often perfect

Table 1: Differences between entertainment games and serious games (Susi et al. 2007).

and the positive impacts on the player's development concerning the extension of knowledge that have been found in research so far. The problems and challenges while evaluating a serious game build the topics of the fourth part. In addition some frameworks are presented which can be seen as one possible empirical approach to evaluate a serious game. But also the limitations of these frameworks are stated in the following. In the last part, the conclusion gives a closing summary combined with supposed future prospects.

2. Serious Games – A definition

By analyzing the actual state of research in the domain "serious game" it becomes obvious that a coherent definition of the term serious game is lacking. There are many definitions which are all similar, but not the same. Zyda (2005) for example points out that serious games are a combination of entertainment and a pedagogy intention. But he emphasizes that the entertainment aspect is the most important one, followed by the story and the pedagogical aim. Michael and Chen (qt. by Susi et al. 2007) define serious games as "games that do not have entertainment, enjoyment, or fun as their primary purpose" (p. 21). They mention that the most important aspect is the purposeful intention to reach a change in behavior. Furthermore Guardiola, Natkin, Soriano, Loarer & Vrignaud (qt. by Mader, Natkin and Levieux 2012) border the concept of a serious game in accordance to Michael and Chen [qt. by Susi et al. 2007] by stating that the main difference between a serious and other games is the demand to have an impact on real life. A similar statement is given by Susi et al. (2007) who ar-

gue that a serious game is a digital game used to purpose other aspects than mere entertainment. In table 1 an overview of the comparison between serious and entertainment games is given. Concluding, it is important to mention that finding a consistent definition for the term serious game in literature is nearly impossible. But nevertheless there are aspects being mentioned in almost every definition: Serious games claim to be more than just entertainment and pursue the serious aim to transfer knowledge in a playful way.

After the previous introduction into the broad term, the following section gives an overview of different domains in which serious games are used.

3. Attempts of classification

The variety of serious games and respective applications is huge. By now, several authors tried to establish a system to categorize the existing games. Yet, there is still no universally accepted practice. Therefore, some reasons may be conceivable. Above all, there are endless ways to classify the huge amount of serious games that have been published in the last couple of years. Despite this notably a lot of games could also be classified into more than just one category. Not least many researchers try to create their own classification system or taxonomy instead of trying to contribute to an already existing one.

Ritterfeld, Cody and Vorderer (2009) developed a classification system based on a dataset of more than 600 serious games in order to facilitate a coherent empirical investigation and analysis of serious games. Ben Sawyer's taxonomy (Sawyer and Smith 2013) relates the different sectors to the existing genres of

serious games. A related categorization proposes that serious games technology can be applied to diverse domains such as healthcare, public policy, strategic communication, defense, training, and education (Serious Games Initiative 2013). Besides there can be found websites that offer a collaborated classification system based on multiple criteria (e.g. Young et al 2012).

A rather rarely used approach is the categorization in terms of gameplay. As proposed by Vik (2009) it can be distinguished between game-based or play-based and also between turn-based or real-time games. There can surely be named significant differences between simulation games and video games in terms of the gameplay. Another method is to find out what domain or sector the game is intended for. For a long time military, medicine, and health care have been the biggest players on the serious games market (Vik 2009). Others are education, government and NGO, marketing and communication or industry (Sawyer and Smith 2013).

The type of classification provided by Michael and Chen [qt. by Susi et al. 2007] is in line with most types of classifications that can be found until now. They divide serious games by application field which could also be described as the game genre. Among others they mention government games, corporate games, military games, educational games and healthcare games as the core segments in the field of serious games.

3.1 Why is a consistent classification necessary?

Until recently, most research on video games focused on the negative outcomes, for instance their potential for

generating addictive or aggressive behavior (Griffith and Hunt 1998). The above section shows that there is a huge demand on games that now focusses on the positive outcomes. But empirical studies that discuss the evidence on the effectiveness of such games are often neglected. A consistent classification system would serve as a first step towards a coherent understanding of possible research methods and adequate measurements of learning, knowledge, behavioral outcomes and especially transfer from the virtual into the real world (Ritterfeld, Cody and Vorderer 2009). Those research methods and measurements are still lacking. To discuss the advantages and disadvantages of serious games and their possible impact on players a consistent classification as well as a consistent assessment is necessary to prove the effectiveness of serious games.

4. Effectiveness of serious games

As described above serious games have become more and more popular in various markets. All try to take advantage of the positive implications that come with the term “serious game”. However, the learning outcomes are not fully examined and empirically tested. The follow-

ing section provides an overview of the types of learning outcomes and shows what evidence for the effectiveness of serious games has been found so far. Furthermore it provides four examples for each type of learning outcome.

4.1 Types of learning outcomes

Wouters et al. (2009) proposed a learning outcome taxonomy based on previous classifications. He provided four categories of learning outcomes. Firstly, the cognitive learning outcome comprises (textual or non-textual) knowledge as well as skills (including problem solving, decision making and situational awareness). Secondly, motor skills imply the acquisition and compilation of certain behaviors. Thirdly, affective learning outcomes include attitude (change) and motivation. Last, the communicative learning outcomes emphasize opportunities to communicate, cooperate or negotiate and hence can improve these skills. Table 2 provides a shortened version of the classification of different studies regarding the taxonomy (Wouters et al. 2009). The Meta analysis revealed that out of 37 included papers (respectively games) 21 showed significant learning outcomes whereas 16 showed none

or inconclusive results (Wouters et al. 2009). The following section presents one game in each type of learning outcome that showed a significant positive impact.

River City (Dede, Clarke, Ketelhut, Nelson and Bowman 2005) as an example for a cognitive learning outcome is a virtual environment for learning in the classroom. It aims to teach students about scientific research and methods, e.g. how to argue on a scientific basis as well as formulate and test hypotheses. The setting can be described as follows: Three diseases spread simultaneously in River City. The students are challenged to solve this crisis by formulating hypotheses based on several background information from different fields of education (e.g. geography, biology or history). The results indicate that the students’ knowledge as well as their attendance increased. Furthermore, students as well as teachers were more engaged and fewer disturbances were observed (Dede et al. 2005). In summary it can be stated that playing the game resulted in a cognitive learning effect particularly the students’ knowledge increased significantly.

The arcade game Silent Scope (Rosser et al. 2007) was used to measure motor skills in the context of medicine. In more detail the question was raised whether surgeons could benefit from playing vid-

Learning outcome	Study	Game	Domain	Results	Effect
Cognition Knowledge	Dede et al. (2005)	River City	Biology	Game > Text	+
Cognitive skills	Wong et al. (2007)	Metalloman	Biology	Interactivity has no effect	/
	Barab et al. (2006)	Quest Atlantis	Writing	Game > Traditional	+
Motor skills	Rosser et al. (2007)	Silent Scope	Surgery	Game experience yields better performance	+
	Rosenberg et al. (2005)	Top Spin	Surgery	Game experience has no effect	/
Affective Attitude	Bouchard et al. (2006)	Half Life	Phobia	Reduction of fear of spiders	+
	Fischer et al. (2007)	Burnout/ Fifa	Driving	Race gamers less cautious than non race gamers	+
Motivation	Clarke et al. (2006)	River City	Biology	Game > traditional	+
Communicative	Brannick et al. (2005)	Asteroids	CRM	PC based simulator > Game + Exercise	/
	Nova et al. (2003)	Spaceminers	Science	Task performance better with awareness tool	+

Table 2: Shortened classification of studies in the taxonomy of learning outcome (Wouters et al. 2009).

eogames since games can train motor skills, eye-hand-coordination, reaction time and so forth (Rosser et al. 2007). The results show that game-playing skills and experience correlate with laparoscopic skills, i.e. distinct game-playing skills result in fewer errors and a faster completion time of the surgical task. Moreover game-playing skills and experience can be a predictor of laparoscopic skills (Rosser et al. 2007).

Affective learning outcomes were examined using the game *Astra Eagle*, a strategy game for children (Ke and Grabowski 2007). The aim is to solve mathematical problems. In short the influence of game-playing on mathematical performance of fifth graders was tested. The results indicate that game-playing is more effective than paper-and-pencil-drill sessions the control group had to complete (Ke and Grabowski 2007) and hence improves the mathematical performances. Furthermore it was shown, that cooperative playing was most effective to evoke a positive attitude towards the subject "math". This was regardless of individual differences between the students.

Spaceminers is an experimental platform to conduct psychological experiments (Nova, Dillenbourg, Wehrle, Goslin and Bourquin 2003). In this case it was used to examine possible communicative learning outcomes. Awareness tools, e.g. chats or a camera of the partners perspective and thereby knowledge about the learning partner and his plans, intentions and knowledge can increase the task performance. The setting of Spaceminers is designed as follows: In the year 2206 the earth's resources are exhausted and the United Nations built several space stations to collect valuable minerals. The research showed that the use of an awareness tool increased the task performance, in this case the collecting of minerals was more successful [14]. However, there were no improvements in the modeling of the partner's knowledge. All results mentioned above show good results on the effectiveness of serious games. Nevertheless a prime example of research has to be mentioned when talking about the effectiveness of serious games: Re-Mission (Kato 2010; Kato, Cole, Bradlyn and Pollock 2008).

The game can be classified as a first person shooter for children with cancer. The patients can learn something about their type of cancer and treatment options by exploring 20 missions and destroying bad cancer cells. The results show an improvement in adherence, i.e. the medication guidelines provided by the physicians were followed strictly. Furthermore, the self-efficacy, life quality and knowledge about the cancer types and treatment options were increased (Kato 2010).

5. The challenge

As stated above there have been some studies on the effectiveness of serious games regarding the learning outcome. However, a lack of evidence remains for most parts of serious games. Furthermore, this leads to the problem that games are declared as serious games although the pursued learning goals are not reached. And because there is no universal definition, there is a lot of room for interpretation. Designers and industry pretend that games labeled as serious games per se are beneficial. The Meta analysis by Wouters et al. (2009) also shows that this is not the truth. 16 out of 37 games had no significant effects. This may be due to an inconsistent approach concerning the study designs and testing methods. This can also be traced back to the fact that there are limitations of empirical studies which can lead to inconsistent results. All in all, empirical research in this area is still at the beginning and there is still no conclusive evidence for the potential benefits and consequences of serious games. To find out more about the effectiveness of serious games, actual changes from a behavioral and cognitive point of view need to be tested in more detail. But why is it that difficult to evaluate serious games? Several reasons can be mentioned.

Firstly, control groups have been used inconsistently throughout different empirical studies (Girard, Ecalle and Magnan 2012). There are no guidelines on how a control group should look like. In some studies it may be a group who doesn't play the game at all, whereas in other studies it may be a group which

gets some kind of different training than the game itself e.g. by pencil-and-paper like in *Astra Eagle*. Girard et al. (2012) raises the question if there is in fact an ideal control group. He argues that some kind of training should be more effective than no training at all. Hence, the serious game should be tested against another method of learning with the same educational content to prove its effectiveness. Nevertheless a comparison between the three types of groups should be used in every empirical study on serious games: no training, training with another method and training with the serious game. Overall there is "no common baseline" (Girard et al. 2012, p. 9) for comparisons between different studies and games yet.

Secondly, it is unclear if the acquired knowledge and skills will be transferred into the users' everyday lives and can be useful in real-life situations (Girard et al. 2012). Did the subjects' behavior change for the long-term after playing the game or did their academic outcomes improve? Questions like this remain unanswered. Different researchers argue that the training used in the games is "usually not sufficiently specific and, consequently, has little impact on real life" (Girard et al. 2012, p. 9).

Thirdly, due to the various different types of serious games it is difficult or even impossible to draw any general conclusions about their effectiveness (Girard et al. 2012). The types of games as well as the skills that are trained have to be considered and vary from game to game.

The challenge is to identify which game elements within a serious game are effective. And it is especially interesting when and why these elements reach their learning goal. But because of the previously named problems it is difficult to draw a conclusion regarding the effectiveness of serious games in general. To sum up, the game type, the learning goal and purpose as well as the variety of game genres require the same variety of empirical methods and instruments. Again, this is what makes it hard to find universal evaluation approaches.

A possible solution might be to go back to the starting point of serious games and take a look at the design

process. A framework to develop serious games could serve as a guideline for the game designers and programmers to develop a coherent serious game which could in turn serve as a solid basis for subsequent evaluation.

5.1 Assessment of serious games: Frameworks

How can researchers design and evaluate serious games? Frameworks as a guideline can help to give some structure to the design and evaluation process.

Brian Winn proposed the "Design, Play and Experience Framework" to discuss and analyze the design and development of serious games for learning (Winn 2007). The framework shows an adequate theoretical background and includes elements like learning, storytelling, game play and user experience. Nevertheless it neglects the purpose and does not reflect the main learning objective of a game.

Annetta, Lamb and Stone developed the "Serious Educational Game Assessment"-Framework with thirteen criteria and game play characteristics. It is an empirical method to evaluate the test results found with the framework (Annetta and Bronak 2011) so that the games' ratings can be evaluated quantitatively. But again, it does not consider the purpose of the game itself.

"Key criteria for Game Design: A Framework" proposes seven elements to analyze serious games including motivational aspects as well as game play characteristics (Sanchez 2013). But the framework did not consider the purpose of the game either which is necessary for evaluating the effectiveness and impact on the learners afterwards.

However, all of these frameworks do not consider the unique characteristic of serious games, namely to learn something and to achieve a certain educational objective. A lot of approaches try to establish some kind of framework to categorize, analyze or develop serious games, but hardly any of these function in the intended way. Especially since a lot of studies only used one specific game to develop and test the framework (e.g. Mader et al. 2012).

The Serious Game Design Assessment Framework

Mitgutsch and Alvarado (2012) developed the "Serious Game Design Assessment"-Framework (SGDA) in the course of a research project on serious games for social change, analyzing 160 serious games during this project. The SGDA consists of six elements (purpose, aesthetics/ graphics, fiction/ narrative, mechanic, content and framing) which are integrated in a coherent and cohesive game system (Mitgutsch and Alvarado 2012). The element "purpose" is or should be the driving force behind a serious game. It is "reflected directly in the aim of the game and its topic" (Mitgutsch and Alvarado 2012, p. 123).

Although this seems to be a good approach, frameworks like the SGDA have got some main limitations. We feel it is necessary to mention the fact that it is not always possible to separate the different elements from each other and analyze them independently. Especially as they are interacting with each other it will be hard to identify the single elements within a game. Furthermore, the intended unique features of the framework still could be used for analyzing normal video games. Unless a further specification is made, the added value for tools like this is not obvious. Hence, the evaluation of the framework remains unsettled. Nevertheless the research project looks promising and may generate a revised framework and solution.

6. Conclusion

Although there is a multitude of respective games and applications on the market the whole concept still lacks some important aspects.

Overall, a universal definition as well as a consistent evaluation system for the various application areas is maybe not realizable. While some authors focus almost exclusively on the purpose and intended learning outcomes of serious games (Michael & Chen, 2006, qt. by Susi et al. 2007), others stress that serious games principally have to be fun and entertaining (Serious Games Initiative 2013). Different terms and related concepts like e-learning, edutainment or

simulations are often used analogously to the term serious games and illustrate some substantial discrepancies and the absent consistent understanding.

Another crucial fact is that most serious games are not well enough evaluated regarding their intended and expected learning outcomes. The missing evidence for the effectiveness of such games is still a much-debated point. Limitations of the literature (e.g. the tendency that only positive findings are being published) as well as the mentioned problems in already implemented empirical studies (e.g. the control group problem) so far led to a clear lack of evidence on the effectiveness of serious games (Girard et al. 2012). Nevertheless, the term serious game might still arouse expectations in society of learning in a rather playful and enjoyable way without any notable effort. Surely this might be one reason for more and more game developers label their software serious game, namely in the hope of ready sale but without having conducted any experimental studies.

To prevent that serious games flood the market without being demonstrated effective, the implementation of many more experimental studies is necessary. To find out about the long-term effects and the expected transfer into real life, the performance of long-term studies is required (Girard et al. 2012). Another possibility would be to only allow the title serious game for games that could show significant learning outcomes.

To sum up, the long-term goal should be the design and development of games of which one can be sure of their positive learning outcomes. This would also imply a radical rethink within the whole serious game industry and market. A reasonable approach is the implementation of design and assessment frameworks. Yet, there cannot be found a lot of frameworks in the literature. The ones that have been proposed so far are often not evaluated or still need some revision. Furthermore, the insufficient focus on serious games has to be criticized. An important factor might be the use of those frameworks at the very beginning of the design process. Only frameworks that reconsider aspects that are essential in the concept of serious games such as the main purpose as well as the learning objective enable a

coherent assessment. Generally speaking, we claim that the evaluation process and method already have to be considered before or at least during the design process of a serious game and that those frameworks are specifically developed with respect to serious games only.

The development of a standardized questionnaire as well as further methods for investigating the effectiveness of serious games could serve as useful tools. Another option would be the development of specific criteria or guidelines that define a video game as a serious game. Further studies and experimental investigation is needed to find out which factors lead to learning outcomes and why. In addition, research in the area of serious games necessarily requires interdisciplinary cooperation where game developers can benefit from the knowledge of psychologists and pedagogues.

Due to its characteristics serious games can surely be a powerful tool in various areas like health or education. We mentioned several researchers and projects that stress the necessity of empirical studies as well as design and evaluation frameworks. Before developing new serious games, adequate tools to analyse and assess serious games are essential to prove the effectiveness and the promising potentials of serious games in the various areas. Apart from that several new markets and further trends are conceivable in the near future, too. For instance, a growth in the mobile and online market concerning serious games is expectable in the next years. Also the collaborative and social aspects of video gaming are possible areas that might be placed special emphasis on by game development and research. Games like Foldit (2008) already show the power and opportunities of online games with such a collaborative and serious background. Thousands of players engaged to solve the problem of protein-folding within a 3D online puzzle game. With the creativity and intelligence of the crowd important steps towards treatment opportunities for the HI Virus were made. Especially the health sector is a promising area as it can already possess some of the best evaluated games (e.g. Re-Mission). Mobile health tracking could be possible with the help of mobile devices and special applications. Maybe

even the visit to the doctor becomes unnecessary when special applications are available for smartphones or tablet PCs that combine the playfulness of a game with the seriousness of one's individual medical condition.

Based on these successful examples and possibilities more elaborated games have to be developed. The beneficial outcomes and potentials of serious games mentioned in the above sections show their importance. Nevertheless the long-term goal, namely the design and development of games that actually present the induced learning outcomes, must not be ignored. Only when the reliability and trustworthiness of the serious games market is guaranteed, serious games will be accepted and can finally serve as powerful tools in the various application areas.

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