

Serious Games and Heuristic Evaluation – The Cross-Comparison of Existing Heuristic Evaluation Methods for Games

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Abstract. Learning by playing has been a desire in the educational domain. The use of serious games may offer the possibility to learn and train at the same time the learner is playing. It makes us consider the serious games as an important research area that can have huge implications in the way the new generations are learning, getting experience, practice knowledge, gain skills, train their habits and reactions. There are many heuristics available in the area of video games, several are presenting repetitive aspects, some are isolated up to the point of reaching contradictory outcomes. The main purpose of this article is to define the nature of serious games and the process of evaluating game. We are taking as the references existing heuristics for games together with their weaknesses and strengths. In order to approach the problem we grouped together and present the most important HEs for games and compiled three sets of heuristic evaluation to identify the areas of tangency.

Keywords: heuristic evaluation, serious games, simulators, usability evaluation, design guidelines, video games, computer games, HCI.

1 Introduction

When considering the serious games as dispositive, that can be used with educational and training purpose, we should assure that the used games are satisfying the educational and training needs. This need makes us think about the importance of conducting a formal evaluation of serious games. Our intention in the future is to build fundamentals for holistic, complete, easily applicable, comprehensive method that will take into account the nature of serious games.

There are two main objectives of this research paper. Firstly, the paper discusses the concept of "serious games". It will be followed by discussion of the advantages of using serious games and illustrate the possibilities of appliance. Secondly, we will

discuss Heuristic Evaluation (HE) for games. Heuristic evaluation has proven to have a very huge potential and to be a valuable assessment method. This research work has extensively presented the existing heuristic evaluation in the area of the games together with their analysis, advantages, limitations and stating the possibilities of applying them into the concept of serious games. We are also presenting the matrix - the cross-comparison of the most cited HEs with their areas of tangency.

2 Serious Games

2.1 Concept of Serious Games

What is exactly a serious game? Can the game framework serve a serious educational purpose? This is the main critics that are presented around the idea of serious games. At first, usage of terminology, serious game, might seem to be mutually exclusive. Indeed, the term serious game can be seen as an oxymoron or as a tautology combining contradictory terms, game - an engaging and amusing activity with seriousness of content and context.

Clark C. Abt [1] already in 1970 presented the richness of the concept of the game that can be in favor for serious games. The main aspects presented in his book were both formally describing the rules of the game and motivation of the players. The games are effective tools for teaching and training for students due to their highly motivating nature and effective way of transferring the concept and facts. Games can create "*dramatic representations of the real problem*" in which students can take realistic roles in order to solve given problems by developing strategies, taking decisions, receiving fast feedback on the progress towards the set goal. What is more games can serve as the tool of evaluating performance and prevent students from taking a risk of solving the problem in real world together with the costs of conducting errors [1].

According to Michael & Chen, the first and main goal of serious game is the educational and training role: meeting specific educational purpose, specific learning aspects, specific training objective offered in many new forms rather than simple entertainment [2]. What is more learning in the game environment is not a hard "work". Learning is based and achieved by solving the problems, experiments and exploration, all the aspects that are keeping the learners active and interested [3].

For the purpose of this research we consider serious games as: specialized learning and training tools that can be used to enrich the process of learning, training, habit creation and the attitude change. It is offered in varied forms and at the same time it uses the main characteristic of game and entertainment factor in order to reach specific educational and training purposes.

2.2 Application and Advantages

There are many classifications of Serious Games. Games can be created for many reasons among which are health, training, education, science, research, production, work and marketing/publicity. The interested group in applying them can include

government together with NGOs, defense/military, healthcare, marketing & communication, education, corporate and industry. Serious Games can be seen from other points such as sociability: allowing collaboration and/or competition and by number of players: single player, multiplayer components and tournaments or massive-online games and simulators. It is also crucial to include hardware in the classification e.g. if the game is available on all type of platforms or is limited to only one e.g., portable consoles, personal computers, tablets, mobiles, XBOX 360, WII etc.

There is the consensus that serious games are the potential tools designed to have the educational impact. Firstly, thanks to using serious games we can raise students engagement and motivation [4-5]. Secondly, the solutions offered by implementing serious games are suitable for even beginners within the computer-mediated system; moreover, they allow students to take more active role in their education [6].

In addition, the games are providing a special feeling of accomplishment during the play, sense of triumph that encourages the immersion in the learning process [7]. Games are improving problem solving, critical thinking, and allow collaboration, socialization with other players [8]. Serious games are perfect method of assessing the knowledge of the students and they allow receiving the immediate feedback on player's performance. There is very strong visible emotional connection between a student and learning material that allow students to do the meaningful choices [9]. Ideally all those characteristics should be presented in school but they are usually ignored or limited [10]. Serious games allow the learners to experience the situations that are normally hard to be experienced in real-life situations because of many limitations such as time, space, safety etc. We cannot ignore the fact that simulations and serious games are allowing the gamers to experience the situation that normally, because of safely and cost-effective reasons, would be impossible. The idea behind the serious games is to intentionally create the learning bridge between the experience of daily life and learning styles [11-12] and provide the situated learning that is long lasting compared to standard learning. What is more, according to many studies, students are preferring games and simulators over the standard class exercises [13].

There was a wide study conducted by Conolly [14] and his colleges in which they revisited the available literature on serious games - they found almost 130 papers presenting the empirical evidences of the significant impact of serious games. The most important areas of the impact that were identified are in the area acquisition of the knowledge, understanding the content and essential rise in motivation and affection. Additionally, it was stressed that we should not perceive the games as the remedy for all the problems and the only good solution; we should distinguish the benefits of using it in the areas of higher-level thinking and social skills. Games can be of great value especially in certain fields like in healthcare [14].

Primack together with his colleges collected and review the wide selection of available studies that are focusing on the impact of video games in healthcare – huge effectiveness of serious games in patient treatment, phobias treatment and acquisition of clinical knowledge and skills by medical personnel [15]. The researchers identified 38 papers in clinical studies. Among health-topics the common topics were asthma, strokes, physical activities and cancer. The results of his studies have proven a significant and positive impact of games in the clinical settings.

3 Heuristic Evaluation for Games

Heuristics Evaluation (HE) has become an extensively acknowledged method of usability evaluation in software development and a current, widely accepted and used method of usability evaluation and inspections. Usability inspections methods are playing important role in the designing a well-structured, effective, learning and training tool such as video game. HE are qualitative method used by the experts in evaluating given problems. HE is the method of finding the usability problems so that they can properly attended and resolved by implementing evaluators who are inspecting and examining given system, software or product [16]. That is why, HE can be perceived as more subjective method than the other usability inspections methods because it is strongly embedded in the skills of the evaluators and their experience [17]. It is possible that those characteristics might have a negative impact but while implementing skilled evaluators into the process of evaluation we can easily find the problems, potential areas of conflicts and inconsistency in the serious games. That is why conducting the heuristic evaluation can be a valuable and significant in the serious game design process from the evaluation the game at its concept stage through game prototype up to final serious game.

Nowadays serious games are considered as fast growing field with varied areas of implementations. There are several heuristics evaluations in the area of games but they are partially applicable or not applicable to serious games' nature. We have decided to present different sets of heuristics created for evaluating games (Table 1.).

Table 1. Heuristic Evaluation for games

Author	Description
Malone, 1982	Set of heuristics for instructional games with the emphasize on challenges and fantasies that can foster the curiosity development and have the impact on learning outcomes. The first HE encouraging to use games in learning and teaching [18].
Federoff, 2002	Proposed a complete set of heuristics that were divided into three groups, game interface, game mechanics and game play. The limitation could be seen in applicability only at the preliminary stage of game design and not covering properly the emotional features of the games and immersion [19].
Desurvire, Caplan, Toth, 2004	Heuristics to Evaluate Playability (HEP). HEP consists of game play, game mechanics, game usability and introduced new class: game story. HEP was a method that was including the narrative plot of the game and the character development during the game play as an important factor. The limitation can be connected with applicability only at the preliminary stage and generalization that could lead to problems with objectivity [20].

Table 1. (continued)

Korkonen, Koivisto, 2006	Set of heuristics to measure playability for the mobile games that include the specifications and limitations of used platform such as power battery limits or size of the screen [21].
Korkonen, Koivisto, 2007	Extended version of previous heuristics for mobile games that additionally included the multi-player dimension [22].
Jegers, 2008	Usability and playability heuristics designed for persuasive games: games that are using one of the three characteristics: i) mobile and place/time independence, ii) social interactions and iii) integration between physical and virtual worlds. Proposed heuristics are focusing on the aspects that have not been covered before by other heuristics in the area of game development such as involving interactions between the players and with the game environment [23].
Pinelle, Wong, Stach, Gutwin, 2009	Usability heuristics for networked multiplayer games - Networked Game Heuristics (NGH). The heuristics were build after detailed examination of the reviews of multiplayer games that are available online. It was the first set of heuristics that was derived from real problem of network games reported by the end users in the game portals: GameSpy and GameSpot [24].
Desurvire, Wiberf, 2009	Game usability heuristics (Play) that was covering the areas of game play, skill development, tutorials, strategy and challenges, game story, immersion, coolness and usability and game mechanics. Play was initially refining the proposed list of heuristics HEP by the following dimensions: multiple types of games and genders. Those features made PLAY applicable mostly at the early stage of game development [25].
Omar, Jaafar, 2010	Playability heuristics for Educational Games including five issues: interface, pedagogical/educational, multimedia, content and playability. It the first available heuristic that was treating the educational aspect as a main objective of games. This set of heuristics was treating the educational features is very general way and not covering the features connected with serious games [26].

4 Matrix of Cross Comparison of HEs for Games

4.1 Methodology and Results

In order to reach the global view of the related works we have decided to analyze in details three set of heuristics for games and video games by cross-comparison:

- Federoff, M.A.: Heuristics and usability guidelines for the creation and evaluation of fun in video games [19].

- Desurvire, H., Caplan, M., Toth, J.: Using heuristics to evaluate the playability of games [20].
- Desurvire, H., Wiberg, C.: Game Usability Heuristics (PLAY) for Evaluating and Designing Better Games [25].

The outcomes are presented in the table below (Table 2.). With the mark "X" we mark the presence of a certain feature. For the sake of clearness he have grouped the features in three distinguished categories:

- Game Play - grouping all the issues connected with the playability of the game;
- Learning and Entertainment - issues connected with fun and learning;
- Usability and Game Mechanics issues together.

It is allowing us to clearly observe the areas of tangency between the sets.

Table 2. Cross-comparison of three sets of HE in the area of games

	Federoff	Desurvire, Caplan, Toth	Desurvire, Wiberg
I Game Play			
1. Game story			
The player feels as though the world is going on whether their character is there or not.	X	X	X
The player is interested in the story line. If possible, the story experience relates to player's real life and grabs their interest.	X	X	X
If there is a game story, the player should discover it as the part of the game play.	-	X	-
If there is a game story, the player is eager to spend time thinking of the possible outcomes.	-	X	-
2. Enduring the play			
The game does not put the unnecessary burden, fatigue, or feeling of discomfort for the player by varying activities and pacing during the game. Players shouldn't be burdened with tasks that don't feel important.	-	X	X
The player should not be penalized respectively for the same failure.	-	X	X
Game play is long, enduring and interesting for the player.	-	-	X
The player experiences fairness of outcomes.	X	X	-

Table 2. (continued)

3. Challenge, Strategy and Pace			
The game is paced in order to apply pressure but without frustrating the player. The game should increase the players' skills at an appropriate pace as they progress through the game.	X	X	X
The game is easy to learn but is harder and challenging to master.	X	X	X
The game challenges are triggering the positive game experience rather than a negative one.	-	X	X
If possible, the game provides different difficulty levels (levels of challenge for different learning activities and for different players)	X	-	-
The players are interested enough to continue playing rather than quitting the game.	-	X	X
4. Consistency in Game World			
The game world reacts to the players and remembers their passage through it.	-	X	X
Changes the player makes in the game world are persistent and noticeable if they back-track to where they've been before.	-	X	X
The Artificial Intelligence (AI) is visible to the player, reasonable, balanced with the player's actions yet unpredictable.	X	X	-
The game should imply mode in the game play but it should be perceived by the player as modeless.	X	X	-
5. Goals			
The game learning goals are clear for the player. The game is presenting overriding, clear goals (both short and long term) early throughout the game play.	X	X	X
The game gives the meaningful rewards that are immersing the player more deeply into the game by moving the player to a higher level or unlocking special achievements. Players should be rewarded appropriately for their effort and skill development during the learning process. If possible, the rewards are increasing the player's capabilities and expanding their ability to customize.	X	X	X
The player is taught skills early that he is expected to use/practice the skills later on during the game play, or right before the new skill is needed.	X	X	X
6. Variety of Players and Game Styles			
The game play is balanced without definite way to win (single optimal winning strategy) but there are multiple paths to win the game.	X	X	X
The first players' actions are obvious and should result in immediate and positive feedback.	-	X	X

Table 2. (continued)

7.Players Perception of Control			
The player has the sense of control and influence onto the game world (like their actions matter and they are shaping the game world).	X	X	X
The player should feel a sense of control over their characters or units and their movements and interactions in the game world.	X	X	X
The players should feel a sense of control over the actions that they take and the strategies that they use and that they are free to play the game the way that they want (not simply discovering actions and strategies planned by the game developers).	X	X	X
Allow player to build the content in the game.	-	X	-
II Learning and Entertainment			
1. Learning			
Shortens the learning curve by following the trends set by the gaming industry to meet users' expectations.	X	X	X
2.Emotional Connection			
The player is developing the emotional connection with the game world and/or game characters (player should feel emotionally involved in the game).	-	X	X
The game transports the player into a level of personal involvement emotionally (e.g., scare, threat, thrill, reward, punishment) and viscerally (e.g., sounds of environment).	-	X	-
3.Coolness & Humor			
The player finds the game fun with no repetitive or boring tasks.	-	-	X
The game is enjoyable enough for the player to be eager to replay it again or replay some specific learning activities.	X	X	-
4. Immersion			
The game utilizes visceral, audio and visual content to further the players' immersion in the game.	X	-	X
III Usability and Game Mechanics			
1. Documentation and Tutorial			
The game provides the interesting and absorbing tutorial that mimics the game play. Players can be taught to play the game through tutorials or initial levels that are giving the feeling of playing the game.	X	X	-
The player does not need to access the tutorial in order to play.	-	-	X
The player does not need to read the manual or documentation in order to play.	X	X	X

Table 2. (continued)

2. Status and Score			
Upon initially turning the game on the player has enough information to get started to play.	X	X	X
Mechanics/controller actions have consistently mapped and learnable responses.	X	X	X
Game controls are consistent within the game and follow standard conventions.	X	X	X
A player should always be able to identify their score/status, learning outcomes and goals in the game without interfering the game play.	X	X	X
3. Feedback			
Provide appropriate audio/visual/visceral feedback (music, sound effects, controller vibration) to stir a particular emotions.	X	X	X
Game provides feedback and reacts in a consistent, immediate, challenging and exciting way to the players' actions.	X	X	X
Use sounds to provide the meaningful feedback.	X	-	-
4. Burden on the player			
The game has varied difficulty levels or tasks so that the players has greater challenge as they develop mastery.	X	-	X
The game controls are basic enough to learn quickly, yet if necessary can be expandable for advanced options for advanced players.	X	X	X
5. Screen Layout			
Art is recognizable to the player and speaks to its function.	X	X	X
The player experiences the user interface as consistent (in controller, color, typographic, dialogue and user interface design). Learning objects and tasks might be varied but all menu instructions, tips or error messages are appearing in the same place on the screen.	X	X	X
The interface should be as non-intrusive to the player as possible.	X	X	-
Make the menu layers well-organized and minimalist to the extent the menu options are intuitive.	X	X	-
6. Error Prevention			
The players are able to play and get involved quickly and easily with tutorials, and/or progressive or adjustable difficulty levels (if the game gives the options to change the level).	X	X	X
The players should be given learning context sensitive during the game play so that they are not stuck and need to rely on a manual for help.	-	X	X

Table 2. (continued)

The players should feel a sense of control over the game shell (can easily turn the game off and on, and be able to save games in different states).	X	X	X
Upon initially turning the game on the player has enough information to get started to play.	-	X	X
The players' error is avoided, players should not be able to make errors that are detrimental to the game and should be supported in recovering from errors.	-	-	X
Provide means for error prevention and recovery through the use of warning messages.	X	-	-

5 Conclusions and Future Work

Serious games are providing an engaging, interesting experience, motivation and self-reinforcement during learning and training. We should not be forgetting it is not remedy for all, the wise implementation of serious games can really trigger the positive impact on learner. When combined together with standard form of training and teaching we can acquire the effect of synergy and create appealing, thought-provocative, inspirational ambient.

It is bound that serious games will be fully integrated into the learning process in the future and specialized training simulations will become an important and integral part of the curriculum as a practical workshops and great assessing method to check the progress of student's knowledge in action.

In order to achieve that we should ensure that used games are meeting our objectives. Heuristic Evaluation has proven to be a very valuable method of assessment. In order to reach the global view of the related works we have decided to analyze the different set of heuristics for games and video games. The outcome of this paper is the cross-comparison between the different heuristics. We have chosen the most relevant HE for the scope of the project, in order to identify uncovered areas and the strong points of each HE. We need to stress out that existing heuristics are not dealing with seriousness and learning features present in the concept of serious games. We noticed the lack of specially established heuristics evaluation methods applicable for the concept of serious games, among which are:

- player's concentration: responses to stimuli, maintaining attention, different responses to workload, distraction and stress;
- social interactions - providing the opportunities for social interactions (competition, cooperation);
- learning content - different types of learning content on different level of games;
- players' immersion - encouraging deep experience yet effortless and natural;
- features concentrated on specialized training games and simulators e.g. for military, air force, firefighters that have specific purposes of training habits, attitudes, behaviors, reactions and other specific learning outcomes.

After conducting a systematic literature revision we have identified the most cited articles, key concepts and principal heuristics evaluations for games with the intention of analyzing the uncovered areas relevant to serious games. In the future it will allow us to conceptualize, develop and introduce a brand new HE for serious games.

References

1. Abt, C.C.: *Serious Games*. Viking Press, New York (1970)
2. Michael, D.R., Chen, S.L.: *Serious Games: Games That Educate, Train, and Inform*. In: *Education*, pp. 1–95. Muska & Lipman/Premier-Trade (October 31, 2005)
3. Edery, D., Mollick, E.: *Changing the game. how video games are transforming the future of business*, p. 218. Ft Press (2009)
4. Lim, C.P., Nonis, D., Hedberg, J.: *Gaming in a 3D multiuser virtual environment: Engaging students in Science lessons*. *British Journal of Educational Technology* 37, 211–231 (2006)
5. Kim, B., Park, H., Baek, Y.: *Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning*. *Computers & Education* 52, 800–810 (2009)
6. Martin, S., Diaz, G., Sancristobal, E., Gil, R., Castro, M., Peire, J.: *New technology trends in education: Seven years of forecasts and convergence*. *Computers & Education* 57, 1893–1906 (2011)
7. Prensky, M.: *Digital game-based learning*. *Computers in Entertainment* 1, 21 (2003)
8. Klopfer, E., Yoon, S.: *Developing games and simulations for today and tomorrow's tech savvy youth*. *TechTrends* 49, 33–41 (2004)
9. Johnson, L., Adams, S., Cummins, M.: *NMC Horizon Report - 2012*. In: *Higher Education Edition*, vol. 2012, p. 42 (2012)
10. Klopfer, E., Osterweil, S., Salen, K., Groff, J., Roy, D.: *Moving Learning Games Forward*. *Flora* 3, 58 (2009)
11. Proserpio, L., Gioia, D.A.: *Teaching the Virtual Generation*. *Academy of Management Learning & Education* 6, 69–80 (2007)
12. Vahey, P., Tatar, D., Roschelle, J.: *Using handheld technology to move between the private and public in the classroom*. In: *Ubiquitous Computing: Invisible Technology, Visible Impact*, pp. 187–210 (2006)
13. Chin, J., Dukes, R., Gamson, W.: *Assessment in Simulation and Gaming: A Review of the Last 40 Years*. *Simulation & Gaming* 40, 453–568 (2009)
14. Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T., Boyle, J.M.: *A systematic literature review of empirical evidence on computer games and serious games*. *Computers & Education* 59, 661–686 (2012)
15. Primack, B.A., Carroll, M.V., McNamara, M., Klem, M.L., King, B., Rich, M., Chan, C.W., Nayak, S.: *Role of Video Games in Improving Health-Related Outcomes*. *American Journal of Preventive Medicine* 42, 630–638 (2012)
16. Nielsen, J.: *Paper versus computer implementations as mockup scenarios for heuristic evaluation*. In: *Proceedings of the IFIP Tc13 Third international Conference on Human-Computer Interaction*, pp. 315–320. North-Holland Publishing Co. (1990)
17. Mack, R., Nielsen, J.: *Usability inspection methods*. *ACM SIGCHI Bulletin* 25, 28–33 (1993)

18. Malone, T.W.: Heuristics for designing enjoyable user interfaces: Lessons from computer games. In: Thomas, J.C., Schneider, M.L. (eds.) *Proceedings of the 1982 Conference on Human Factors in Computing Systems*, pp. 63–68. Ablex Publishing Corporation, Norwood (1982)
19. Federoff, M.A.: Heuristics and usability guidelines for the creation and evaluation of fun in video games. *Chemistry & Biodiversity* 1, 1829–1841 (2002)
20. Desurvire, H., Caplan, M., Toth, J.: Using heuristics to evaluate the playability of games. In: *Human Factors and Computing Systems, CHI 2004*, p. 1509 (2004)
21. Korhonen, H., Koivisto, E.M.I.: Playability heuristics for mobile games. In: *Proceedings of the 8th Conference on Human-computer Interaction with Mobile Devices and Services*, ACM (2006)
22. Korhonen, H., Koivisto, E.M.I.: Playability heuristics for mobile multi-player games. In: *Proceedings of the 2nd International Conference on Digital Interactive Media in Entertainment and Arts*, pp. 28–35. ACM (2007)
23. Jegers, K.: Investigating the Applicability of Usability and Playability Heuristics for Evaluation of Pervasive Games. In: *Third International Conference on Internet and Web Applications and Services, ICIW 2008*. IEEE (2008)
24. Pinelle, D., Wong, N., Stach, T., Gutwin, C.: Usability heuristics for networked multiplayer games. In: *Proceedings of the ACM 2009 International Conference on Supporting Group Work*, p. 169. ACM (2009)
25. Desurvire, H., Wiberg, C.: Game Usability Heuristics (PLAY) for Evaluating and Designing Better Games: The Next Iteration. In: Ozok, A.A., Zaphiris, P. (eds.) *Online Communities*. LNCS, vol. 5621, pp. 557–566. Springer, Heidelberg (2009)
26. Omar, H., Jaafar, A.: Heuristics evaluation in computer games. In: *2010 International Conference on Information Retrieval & Knowledge Management (CAMP)*, pp. 188–193. IEEE (2010)